

Research on Risk-based Passenger Differentiation Techniques Applied to Aviation Security Screening

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Abstract: With the WHO declaring that the COVID-19 no longer constitutes a public health emergency of international concern, the civil aviation industry is poised for a retaliatory rebound in the volume of air passenger numbers. In order to ease the pressure of airport security screening, advanced technologies have been applied in many airports. However, most of these technologies focus on the prohibited items that passengers carry rather than the passengers who carry these items. The optimized utilization of advanced technologies requires risk-based passenger differentiation. This approach includes development of a risk score through behavior-based and data-based differentiation, assignment of the risk score to an individual passenger and incorporation of the score into the security screening process. As most of these techniques are carried out behind-the-scenes, or in a covert and stand-off way, security is enhanced without compromising most passengers' seamless travel through the airport, and therefore achieve the balance between facilitation and security.

1. Introduction

In order to ease the pressure of civil aviation transportation and improve passenger experience, new technologies have been implemented in airport security screening under the umbrella of seamless travel, including millimeter wave (MMV), Computer Tomography (CT), and Automated Target Recognition (ATR), etc. With the development of such technologies, the detection of prohibited articles is becoming quicker and quicker [1]. However, being quick tends to be the opposite to being secure. How can we find optimum balance between quick and secure? "Smart Security" needs to break through. In terms of "Smart Security", we should not only focus on the prohibited items that passengers carry but also on the passengers who carry these items. The realization of "Smart Security" requires passenger differentiation by focusing on high-risk passengers while expediting the low-risk passengers. With the help of innovative behavior detection, biometrics and big data, risk-based passenger differentiation techniques may turn out to be a perfect way to achieve the balance between facilitation and security.

2. literature Review

In previous studies, some scholars have applied the idea of passenger differentiation to aviation security screening. Robert and George first proposed a risk-based passenger differentiation, which

divides passengers into three categories: high-risk passengers, low-risk passengers and ordinary passengers. High-risk passengers undergo strict and complex security screening. Low-risk passengers undergo expedited screening process, while ordinary passengers go through basic and normal procedures [2]. According to the false alarm rate of prohibited articles and the number of security screeners needed, Rajan and Colin proposed an airport security screening system based on passenger differentiation, and utilized the passenger grouping strategy to make the passenger screening system more effective [3]. Laura and Adrian proposed a system that can automatically pre-screen and identify passengers' risk level. Passengers are determined to go through different security screening procedures according to their risk level, the overall security and efficiency are improved to the maximum extent, and the passenger differentiation strategy is optimized [4]. Karl and Thomas divided passengers into different types by cost structure and expected monetary value, optimized the passenger pre-screening system with Bayesian Decision model, and established the Bayesian Decision model of the two pre-screening systems [5]. Zhao Zhenwu introduced his idea of risk-based passenger differentiation, analyzed and calculated the system according to the actual conditions of some Chinese airports [6]. By analyzing the actual sample of airline passengers, Feng Wengang and Jiang Zhaoifeifan made the dynamic analysis of the risk evolution of airline passengers based on passenger differentiation technique [7].

According to the researches of these scholars, passenger differentiation will become an important development trend to reduce the pressure of security screening, improve passenger satisfaction, and ensure aviation security. However, most of these studies are conducted before the outbreak of COVID-19. Therefore, it is necessary to combine the passenger differentiation system with present situation, and establish a new risk-based screening model that fits in with the idea of “Smart Security”.

3. Definition and Process

As opposed to “one-size-fit-all” security screening, risk-based differentiation approaches are a range of techniques to determine the level of risk one or more passengers may pose to an airport or aircraft. Through risk assessment of passengers, different security screening resources are allocated proportionally to passengers with different risk levels. The selected high-risk passengers have to undergo relatively enhanced security procedure, while the low-risk passengers only need to undergo expedited security process.

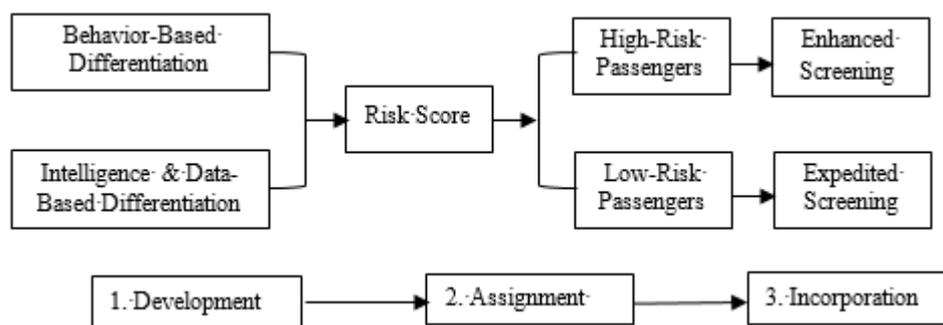


Figure 1: The process of risk-based passenger differentiation technique

Risk-based passenger differentiation approach includes the following steps: 1) Development of a risk score through “behavior-based differentiation” and “intelligence and data-based differentiation”. 2) Assignment of the risk score to the individual or group of individuals. 3) Transmission and incorporation of the score into the security screening process (enhanced or expedited screening). (As shown in Fig. 1)

4. Behavior-Based Differentiation Techniques

Behavior-based differentiation, which is also known as profiling, is the technique that provides passengers with a risk score in real-time at the airport just prior to security screening. It focuses on the extent to which a passenger conforms to the security officer's expectation of behavior for passengers traveling on a given day, at a given time, as well as on the passenger's general demeanor [8]. Instead of identifying threat items, it concerns about the passenger's intent.

4.1 History of Behavior-Based Differentiation

In the 1970s, Israel was one of the first countries to carry out behavior detection in the field of aviation security as a key component of the security strategy. Israeli airports implement different security measures according to passengers with different risk levels. The initial screening is conducted by multilingual psychologists before the passengers enter the security lane. They ask questions such as the purpose of the trip, and based on the passenger's response and answers, determine whether the passenger is lying and what the initial risk level of this passenger is. Passengers with different levels of risk will be directed to different security screening lanes [9].

In the United States, the Transportation Security Administration (TSA) launched the Screening Passengers by Observation Technique (SPOT) Program in 2006, just after the event of 9-11, 2001. Behavior Detection Officers (BDOs) are deployed at the airport to observe the behavior of passengers entering the airport, so as to identify individuals with high potential risks and carry out strict security checks. In 2011, SPOT Program added the process of inquiry. After passengers show their boarding passes and identification, they are asked to answer questions from BDOs, who receive at least 2 weeks of special training, to determine if they are reacting in a suspicious way. BDOs interview people only after identifying suspected targets to get a more detailed picture of passengers, allowing them to focus on those who pose a threat to aviation [10]. BDOs perform behavioral analysis through direct interaction with the passengers. This is through the use of targeted security questions, or simply by engaging in conversation to clear the passengers. BDOs directly engaging with the passengers at the front of the queue or at the entry to the security screening lanes provide the advantage of directly guiding passengers into the appropriate lane.

4.2 Controversy of Behavior-Based Differentiation

Behavior-detection program, which serves as an additional security layer, can positively enhance the aviation security. However, not everyone raves about this program. Some view it as positive customer service, others regard it as off-putting. The use of behavior detection to filter passengers takes time and may alter passengers' seamless journey in departure. In some airports with full behavior detection, airlines remind passengers to arrive at the airport 3 to 4 hours before departure, which is about twice the time requested in most airports. Furthermore, airports outside of Israel and United States have somewhat been reluctant to introduce full behavior detection, given the related training and staffing costs, as well as privacy concerns. With the development of AI technology, automated behavior detection may well be used at airport security in the next few years to replace or supplement current BDO's work.

4.3 Automated Behavior Detection

The use of AI technology enables the automated behavior detection to select high-risk or low-risk passengers in an automatic and efficient way.

1) Movement Pattern Detection

Closed-circuit television (CCTV) can now be offered as an intelligent solution to automatically detect loitering (an unusual flow of passengers through a security checkpoint), or the presence of an unattended baggage. Video images where unusual behavior is detected could be recorded for officer review. Further scrutiny of the passenger could then be undertaken at the checkpoint prior to screening to determine both if the alert is genuine and the level of screening the passenger should undergo. The objective of video-analytics technology is to monitor public spaces for suspicious activities or items/baggage [11]. This technology is also expected to detect some more subtle behavioral anomalies, enabling further action at the checkpoint.

2) *Automated Questioning*

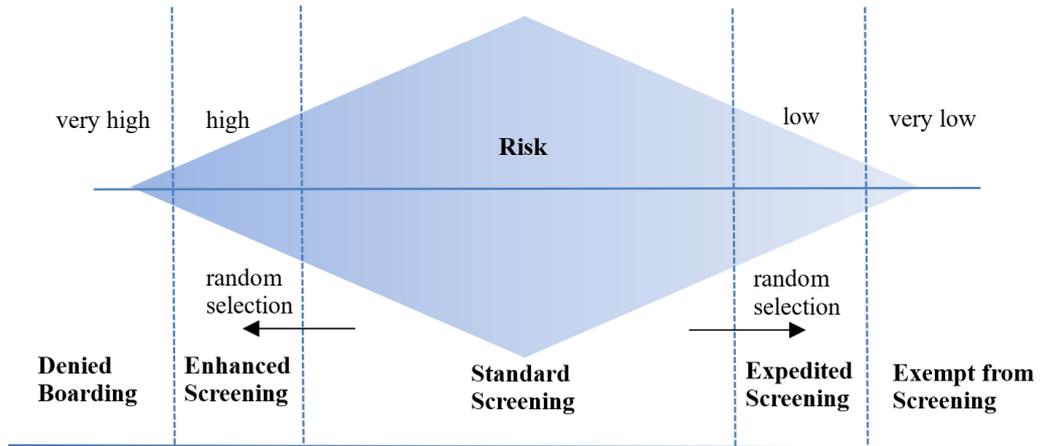


Figure 2: A diagram of risk categories

Kiosks are currently being tested with an avatar asking the user a specific set of security questions. The avatar records the answers and transmits them to a tablet handled by an officer. The officer analyses the passenger’s responses and behavior along with a green, yellow or red color to indicate the level of risk. The risk allocation is based on speed of speech, pitch, tone, and other unusual response patterns. The officer may then alert screeners at the checkpoint that the passenger should be subject to further scrutiny [8]. Automated analytics related to the responses are anticipated in the next few years.

3) *Facial Thermogram*

Research is now at an advanced stage into the development of a non-invasive lie-detection system. In the future, this technology could analyze thermal images of passengers’ faces as they pass through the security checkpoint and generate a risk score for each passenger according to his or her behavior. The technology is not completely stand-off, as the passenger will have to stop and answer questions in order to be assessed. However, unlike the traditional lie-detection machine, there is no physical contact with the system.

4) *Layered Voice Analysis*

Similarly, layered voice analysis technology could allow for the real-time differentiation of passengers prior to the checkpoint. Layered voice analysis technology detects the emotional cues in speech by identifying various types of stress levels, cognitive processes, and emotional reactions that are reflected in different properties of the voice. This information provides insights into the way the subject thinks, what troubles them, what excites them, what portions of their speech they are uncertain about, what questions require more of their attention, and what areas appear to be sensitive issues for the speaker [8].

Automated behavior-detection techniques should not add significant time to the processing of the passengers and alter the seamless travel through the airport. In this way, they will balance the objectives of behavior-based differentiation against passenger experience. Technology solutions should not take up too much space in the airport and ideally should be integrated with other process

touch-points. As an additional filtering process not a core screening function, they should have an appearance appropriate to their location and, if covert, should not be noticeable as an added layer of security.

5. Intelligence and Data-Based Differentiation

Apart from real-time behavior-based differentiation approach, another effective passenger differentiation technique is based on the use of intelligence and data received in advance of a passenger's travel. This model may include Rule-Based Approach and Passenger Information-Based Approach.

5.1 Rule-Based Approach

The majority of passengers could be considered as Normal Risk, with a smaller proportion either requiring enhanced or expedited screening, and an even smaller proportion denied boarding or exempt from screening (as shown in fig. 2). The purpose of rules-based differentiation approach is to identify passengers who fall into the categories on the left or right of the diagram above by using series of rules. Rules include population-based selection, focusing on the particular category to which the passenger may belong, and itinerary-based selection, focusing on the routing of the passenger involved.

1) *Population-Based Selection in Conjunction with Itinerary-Based Selection*

Passengers may be identified into different populations based on the rules applied. Such rules could focus on passengers' age, profession, professional rank, airline loyalty or frequent flyer status, background check status, and so on. For example, the police or military personnel, CEO of a large company, airport ID holders, regular customers, passengers under the age of 10 or over the age of 75 can be classified as low-risk category [12]. On the other hand, people who are accessible to dangerous materials may be classified as high-risk category.

As another rule-based differentiation approach, itinerary-based selection can be used to assign risk scores to categories of passengers based on their travel itineraries [13]. For example, families traveling to or from a holiday destination may be considered lower risk than passengers who are traveling alone to or from a high-risk location.

When using rule-based approach for high-risk or low-risk categories, airports should combine several techniques, using both population-based and itinerary-based selection simultaneously. For instance, a first-class passenger over 75 traveling to San Ya Hainan Island could be provided an expedited screening process based on the combination of criteria.

The selection of passengers of different risk levels based on rules (population/itinerary-based selection) would be carried out in advance of the passenger's arrival at the airport and incorporated into the passenger's barcoded boarding pass for scanning at the entry of security screening checkpoint to designate the appropriate level of screening. E-gates can be deployed at the entry to automatically divert passengers into different lanes. Rule-based approach is the key component of a passenger differentiation process that can effectively balance risk against passenger facilitation.

5.2 Passenger Information-Based Approach

In terms of data-driven differentiation, airports can use passenger specific information to attribute a passenger risk score, which designate the level of screening the passenger is to receive at the checkpoint. This approach is to collect the data of passenger's booking, well in advance of the passenger's arrival at the airport. This advance data can be supplemented by other data collected on the passenger during check-in, baggage drop, ID authentication, and other touch-points. A risk assessment based on passenger data could use any of the following datasets: Advance Passenger

Information (API) data, Passenger Name Records (PNR) data pulled from reservation systems, Departure Control System (DCS) data pulled at check-in.

1) *Advanced Purchased Information (API)*

Found in the machine-readable zone of the passport, a passenger’s biographic details provide travel document information. This basic common dataset is known as Advanced Passenger Information (API). API data can be used to identify those individuals who are already considered dangerous by law enforcement so that appropriate action can be taken. This data could be used to mandate enhanced screening for higher-risk passengers, or to deny boarding to such passengers. The way is to make a one-to-one match against a watch-list. If a match is found, a denied boarding result is communicated to the airline, even if boarding pass has been issued. In other cases, a passenger may be identified as a selectee. The “selectee status” would match with an elevated risk assessment. This means he is allowed to board but should be subject to further scrutiny.

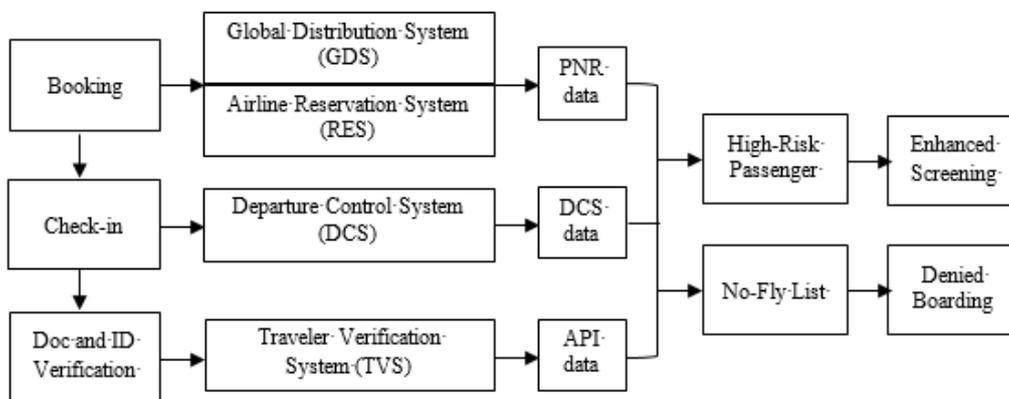


Figure 3: Data sets and data flows in passenger information-based risk assessment

2) *Passenger Name Record (PNR)*

Passenger Name Record (PNR) includes all data connected with the passenger’s booking and ticket purchase. It contains such information as the passenger’s itinerary and mode of payment. This data exists within Airline Reservation System (RES) and Global Distribution System (GDS). By processing the various datasets together with previous travel records, PNR could be used to determine higher-risk individuals who are not already known. This type of analysis would be the detection of unusual booking patterns, certain types of payment, unusual baggage requirements, as well as the detection of anomalies by combining current data with previous travel records and the records of other law enforcement agencies.

3) *Departure Control System (DCS)*

A third type of data comes from the check-in process and is known as Departure Control System (DCS) data. DCS data can include seat number, baggage details, accompanying passengers, and time of check-in. DCS data is collected to supplement API and PNR data to detect unusual travel patterns or behaviors, such as traveling with no baggage, or last minute check-in. By combining API, PNR and DCS data, airports will be able to determine a passenger’s comprehensive profile which can be used for security screening (as shown in Fig. 3).

Intelligence and data-based differentiation is entirely conducted behind-the-scenes. The techniques of assigning risk scores by using individual passenger data is out of view of the passenger population. Not until the passenger has arrived at the airport security preparation and queuing areas is he aware of his potential risk score and the specific screening lane he should go through.

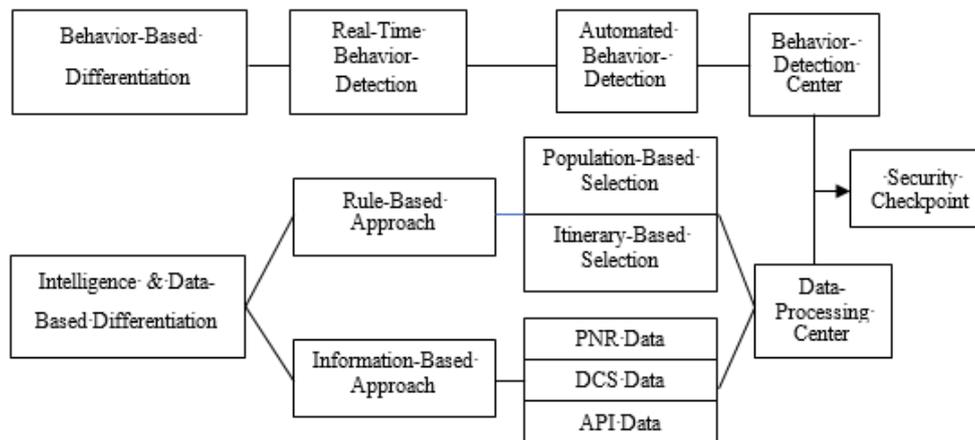


Figure 4: The connectivity of risk-based passenger differentiation

Risk-based passenger differentiation techniques call for real-time connectivity between risk analysis systems and security screening management systems. Airports should look to establish robust connectivity between behavior-detection center, data-processing center and security checkpoint to update the risk assessment and incorporate the risk scores into the security screening process (as shown in Fig 4). With this connectivity and advanced identity management technique (e.g. biometric technology), it is possible to allow for automated entry to the checkpoint. The results from the risk assessment will be communicated in real-time to direct a passenger to the appropriate screening lane in an automatic way.

6. Conclusion

With the WHO declaring that the COVID-19 no longer constitutes a public health emergency of international concern (PHEIC), the civil aviation industry is poised for a retaliatory rebound in the volume of air passenger numbers. The current technology is not able meet this challenge. Therefore, the efficiency of security screening has become increasingly important. In an effort to facilitate efficiency, airports around the world are meant to implement “Smart Security”. With the innovative behavior-detection techniques, together with AI technology and big data, we can differentiate high-risk and low-risk passengers to make airports utilize screening resources in a more efficient manner. We believe that AI, intelligence-driven and data-driven approaches will have a major say in the future security screening concept of operation, and risk-based passenger differentiation technique is a case in point.

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