ARINC | airports

White Paper:
Assessment of
1-to-Many matching
in the airport
departure process

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Rockwell Collins

Background

The airline industry is experiencing significant growth. With higher capacity airplanes, flights along major routes increasing and passenger demand growing, all indicators point to more people in more planes going more places. And in fact, International Air Transport Association (IATA) figures from January – July 2015 show a passenger traffic growth of 6.5% compared to the same period in 2014. This increase in demand is driving airports to evaluate numerous technologies that can more efficiently process passengers while also enhancing security.

One technology airports are looking towards to accomplish this is the use of biometric facial recognition as part of the airport screening process. While the majority of international airports currently use human or a combination of human/technology for passenger screening, in this paper, we will focus our attention on examining the merits of two alternate processes for biometric facial recognition that can be used in the airports departure process.

Over the last few years, facial recognition biometrics have been deployed extensively across multiple use cases and multiple industries. Not surprisingly, many believe that the application of biometrics is particularly valuable in airports. Specifically, the use of biometrics can cut waiting times, increase security and restrict the ability for someone to change their identity.

DEFINITIONS

False Acceptance: When the biometric matching algorithm incorrectly matches the subject with a reference image in the gallery.

False Rejection: When the biometric matching algorithm fails to spot that the subject has a reference image in the gallery.

In this paper, we will review two different approaches to the deployment of biometrics and their application to the airport departure process:

1. 1-to-1 matching (Verification)

In this case, a single enrolment is compared to live images of an individual. A decision is then made to determine if the person presenting is the same as the one who was the subject at enrolment. This test answers the question: "is this the same person that was seen before?" In most cases, the single enrolment is recovered on the presentation of a unique token such as a Bar Coded Boarding Pass (BCBP) or passport.

2. 1-to-Many matching (Identification)

In this case, an individual is compared to a gallery of people that have been enrolled previously. This test answers the question "have I seen this person before?" No token needs to be presented, as the search for the individual is based on a gallery of previously captured enrolments.

The 1-to-Many approach operates by ordering the gallery of images according to those most likely to match the subject. A color-coded determination of identification is then made if there is:

- a single enrolment that exceeds a given threshold (a Green result).

- more than a single enrolment that exceeds the threshold (an Amber result). Then an "uncertain" result is presented, as more than one person could be a match.

- no enrolment that exceeds the defined threshold for matching (a Red result). This indicates that the person hasn't been seen before.

Biometric Application to Airport Departures

The 1-to-Many matching approach is being promoted for use in airports because it removes the requirement for the passenger to produce a BCBP or passport—effectively, the passenger's face becomes the identification token. This is thought to provide a better experience, enabling travelers to be processed more quickly by eliminating the time it typically takes a passenger to find—and a security official to review—the necessary document(s).

This method relies on the capture of an enrolment which can occur as part of the arrivals process, or at the first touch-point in the departure process. With the passenger's permission, enrolments can be retained to make subsequent journeys easier.

Using 1-to Many facial recognition extends the use of biometrics beyond the 1-to-1 matching currently being used in the Common Departure Lounges (CDL) at Heathrow and Manchester Airports. At these two airports, a passenger must present a BCBP to initiate the process at a touch-point and a suitable match to the facial enrolment associated with that unique token must be achieved before they are allowed to proceed.

Biometrics and Airport Security

Beyond improving the passenger experience, as noted above, the two types of biometric identification discussed also have implications for airport screening and thus security.

In the CDL scenario, the consequence of a False Acceptance would be that a person may bypass immigration checks as they enter the country. This result is unacceptable, so biometric thresholds are tuned to ensure that False Acceptance will not occur based on a 1-to-1 approach. As a consequence, however, False Rejection (when the biometric matching algorithm fails to spot that the subject has a reference image in the gallery) rates increase. Ultimately, the system has to be tuned to balance the need for security against the passenger processing time required. However, this tuning will be more challenging if we are using 1-to-Many instead of 1-to-1 biometric facial recognition, as error rates are higher and we must limit False Rejection to operate the process effectively.

Deployment of the 1-to-Many approach may be less challenging in other scenarios, depending on the purpose of the touch-point. For example:

- At check-in—the biometric for registered passengers may be used to identify a passenger and link them to their BCBP, allowing them to drop their hold baggage.

- At pre-security— it is being used to recover the passenger's BCBP and check that they can proceed to airside security checks. Additionally, by integrating biometrics with an airport's Flight Information System or the Airport Operational Database, biometric screening can also help answers questions such as, " is there enough time to get to the plane from here?", "is this the right airport?" and "is this the right day for departure?" Note that this touch-point must also manage passengers that have yet to enrol (i.e. those that check-in at home) and are not checking bags for the hold. This lead to a further requirement to prevent duplicate BCBPs from being presented.

- At government emigration—it is being used to recover the passenger's passport and visa details, enabling officials to check as to whether this is a person of interest.

- For lounge access—it may be used to determine that a passenger is permitted to use the area, based on membership of the airline loyalty scheme.

- At self-boarding—it is used to recover the passenger's BCBP and run through the boarding process with the airline Departure Control System (DCS). The aim of the check is to confirm that the same person that deposited any luggage is the one that boards the plane.

As the table below details, the consequence of an error will depend on the point in the process where such an error occurs and the impact may be mitigated depending on whether there is any possible intervention that could occur.

Touch-point	Implication of Identification Error	Intervention
Check-in	A passenger may be issued with the wrong BCBP.	The passenger is likely to notice the issue and resolve with an airline agent.
Pre-security	A passenger may be allowed to proceed to the next step of landside/airside border checks based on the wrong BCBP information. This may mean that they have entered the wrong zone, or that they have been allowed to proceed based on information pertaining to the wrong flight. In contrast, the passenger may also be denied access based on this wrong flight information.	The passenger is likely to notice when they don't see their departure on the display screens in the lounge. They will then seek resolution with Airport or Airline staff.
Emigration	Exit controls are based on assessment of the wrong person. Individuals could be interviewed as a result or allowed to leave when they shouldn't be.	Officers will probably detect the issue following interview and can request the passenger to present appropriate documentation to resolve the situation.
Lounge-access	A passenger may be granted access in error	At a staffed desk this may occur as part of dialogue with the airline agent, especially if the passenger has been denied access incorrectly.
Boarding	A person is allowed to board who may not have the appropriate documentation and a false rejection means that a passenger is moved to the manual process of assessment.	False rejection is resolved as part of the alternate manual process. False acceptance may be addressed by cabin staff at the entry to the aircraft.

Most of these outcomes represent poor passenger service, but don't necessarily represent an increased security risk, particularly when compared to the implementation of the current human-based process. Others, however, such as self-service routes for emigration which would not be subject to intervention, may be considered to have more serious consequences.

The Application of 1-to-Many

The issues surrounding the uncertainty of the outcome of 1-to-Many searches are compounded by the size of the gallery against which the search is performed. The size of the gallery is affected because of the differing scenarios surrounding enrolment capture. Enrolements can be recorded in any of the following scenarios:

1. Passenger enrols at first touch-point in the departure process.

2. Passenger enrols during immigration and biometrics are retained for use in departure from the same airport.

3. Passenger enrols during immigration and biometrics are retained for use in any subsequent departure or arrival (Registered Traveller Scheme).

The populations of enrolments that make up the gallery vary depending on the scenarios in play. If the system does not have access to the manifest of passengers expected at the airport, then the 1-to-Many search may have to compare against a gallery of all recorded enrolments when a passenger approaches the pre-security check. Over time, this gallery will become very large, either leading to false rejections ('not sure if we have seen this person before') or false acceptance (make an error in identifying the passenger). It is arguable, however, that the likelihood of the impact of a mistake at this point is relatively low. Some passengers may be allowed access based on the wrong information, but the improvement in service for the majority may make this a price worth paying – it all depends on the view of security at this point. We should also remember that the current test that is performed is based on a Bar-Coded Boarding Pass alone; you only need to get hold of the IATA definition and it's not too difficult to create a barcode that would allow you access now. Biometrics are potentially making this possibility less likely. Emigration checks, in contrast, will likely take a different view. The consequence of an error at this point are likely to be considered more serious and authorities will need to be convinced that an unsupervised check based on a 1-to-Many search can operate to the standards required.

As we move to airline-controlled touch-points later in the process, the gallery can be reduced in size assuming we can utilise the expected manifest of passengers on a flight. Self-Boarding, for example, could limit the gallery to the occupancy of the plane. The likelihood of making a mistake here is significantly reduced as a result. Perhaps this is the place where the application of 1-to-Many makes the most sense, as it further simplifies boarding, which is often the most time critical part of the passenger journey.

In any event the aim must be to minimise/eliminate the occurrence of false acceptance without increasing false rejection to unacceptable levels.

Value Proposition

In our view, 1-to-Many Identification should be considered as a means to grant access to passengers at touch-points in the airport. It has significant advantages for the passenger and has developed to the stage where it can provide an alternative to the current implementations, which require manual document scanning. However, it's important to manage the gallery size and be clear on the implications for security, operational impact and overall passenger experience.

Addendum 1: Error Rates in Deployment of Biometric Solutions

The deployment of a 1-to-Many identification approach is subject to higher error rates than a 1-to-1 assessment. Error rates are expressed in terms of False Acceptance Rates (FAR) and False Rejection Rates (FRR). Curves can be plotted which show the variance of FAR and FRR against different galleries.

This allows a system to be configured to operate with a balance of these factors. Normally we want to operate with a FAR of 0, and we accept that there may be a non-zero FRR. The measure of a non-zero FRR depends on the gallery size, amongst other factors, hence we expect smaller error rates for smaller numbers of images in a gallery.

In our experience, FRR tends to zero for galleries containing hundreds of people. Statistical measures for tests based on larger populations, such as what is likely to be expected at an airport terminal, suggest that an error rate of 1 in 100,000 attempts may occur. However, this does not equate to: "it will get it wrong once in 100,000 people". What this means is that there is a 1 in 100,000 chance that a mistake will be made on any one occasion. We suspect that this is much better than human comparison performance.

Addendum 2: The Impact of new Artificial Intelligence learning techniques

Progress in the development of facial recognition accuracy has been assisted in recent times by new techniques based on artificial intelligence which, given enough data, can deliver radical improvements in performance. These improvements may allow the operation of 1-to-Many Identification is viable whilst maintaining a zero false acceptance rate. This is not to say that 1-to-1 Verification is not needed, as it still remains a more accurate measure. Indeed it may be required as part of a system implementation when an Amber result is returned from the Identification check.

About Rockwell Collins

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For more information, contact:

Rockwell Collins
Pegasus One, Pegasus Place, Gatwick Road
Crawley, West Sussex, RH10 9AY, UK
+44 1293 641200
emea@arinc.com
rockwellcollins.com/arinc/airports

Rockwell Collins