Feasibility Study of a New Security Verification Process Based on Face Recognition Technology at Airport

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Abstract: In order to optimize the mode of manual security identity verification at security checkpoints in the domestic airports in China, this paper proposes a new security identity verification process based on face recognition technology. This paper also presents the carried out practical tests on the feasibility and effectiveness of the proposed process. The new process includes two important steps: self-service centralized verification and automatic face recheck of passengers. The test results show that the process is effective and cost efficient. The technology significantly reduces the rate of human error, dramatically relieves the workload of the security staff and shorten the passenger’s time spending at identity check in the airport.

1. Introduction
Identity verification at airport checkpoints is the key security measure of safeguarding civil aviation against the acts of unlawful interference. The identity of a passenger shall be verified at designated checkpoints before access is allowed to airside areas and security restricted areas according to Annex 17, Convention on International Civil Aviation. Its quality and efficiency are related to the effectiveness of the entire civil aviation security system. The current domestic security verification in China mainly relies on manual verification. The common practice is passengers present their boarding passes and ID cards (or passports) at the security counter. The security staff reads personal information generated from the ID card reader, compares the passenger’s facial features with photos of their ID cards. This kind of manual operation mode is not highly automated. The staff is easily prone to fatigue that leads to human error, which would further certain security risks to airport security. With the increasing number of passengers, more security staff are required to perform mechanical repetitive service duty, which results in problems such as shortage of security personnel, unnecessary high work intensity, and fatigue of staff. Against this background, it is crucial to apply new technologies and processes to improve the efficiency of security verification.

Recently years saw the wide application of face recognition technology in the fields of finance, judicial system, education, border control [1] and public security such as in airport [2-3]. The deep learning [4-5] of the face recognition methodology and theory naturally improves its accuracy with a large margin [6-7]. Compared with other biometrics, face recognition technology is of unique merits: contactless capture, non-intrusive, low detection cost and user-friendly interaction, representing one of the most efficient ways of human-computer interaction in the future. Currently, the One ID program [8-9], which aims to improve efficiency and convenience by applying biometric identification, was an
initiative of the *International Air Transport Association* and supported by *Airports Council International*. While in America, the *Transportation Security Administration* [10] began testing and evaluating face recognition technology at the airports to automate the identity and boarding pass verification process. In general, there are few studies on intelligent security verification procedures, and security policies and regulations are different in various jurisdictions. Hence, the application of new technologies and procedures needs to take into account the existing security infrastructure and local conditions.

In this paper, a new security verification scheme based on face recognition technology is proposed, and its effectiveness has been verified in real environment. The testing results show that the scheme is feasible and effective. It enjoys the following advantages: (1) it can effectively reduce the rate of human error, preventing people using fake ID card from passing through the security check; (2) dramatically reduce the workload of security staff, optimizing the allocation of human resources for security check, and (3) enhance the efficiency of identity check, and improve passengers' satisfaction with security check services.

### 2. Intelligent security verification process

#### 2.1. System layout and composition

The purpose of the intelligent security process proposed in this paper is to completely change the conventional mode of manual security verification at checkpoint of civil aviation airports via face recognition technology. As shown in Figure 1, the passenger intelligent security verification area is located at the front of the security check area. The process includes two important steps: (1) self-service centralized verification of passenger's identification and boarding pass and (2) automatic face recheck of passengers. In the process, passengers can choose the automatic face recheck channel for secondary validation after centralized verification, which will change the original working mode that sets a manual verification post in each security screening channel.

![Figure 1. Overview of the security identity verification process](image)

The self-service centralized verification system is located at the front of the verification area, which is a double-gate system that can perform 1 to 1 face verification. After a passenger scans the ID card, the system takes a photo of the passenger, and automatically verifies that the name on the ID card that has already checked-in. It also confirms the consistency between the ID card photo and the photo taken by the camera on site. Self-verification passengers only need an ID card without showing a
boarding pass. In this area, passengers can choose to go through self-verification or to the manual verification counter. The system also collects passenger's information when confirming the identity of passengers at this stage, the collected face information is stored and transmitted to the face recheck module for use. It is worth mentioning that, in order to protect the privacy of passengers, the storage and transmission of face information in our study are processed by the IDEA (International Data Encryption Algorithm).

Passengers enter the automatic face recheck area after self-verification. The face recheck system is a single gate system, which is located at the front of the security screening channel, and perform 1 to N face reconfirmation. In practice, the number of automatic face recheck systems can be determined according to the passenger throughput and the existing site layout, and one automatic face recheck system can be placed at the front of several security screening channels.

The face automatic recheck area has retained a manual check counter, which is designed to handle exceptional situations such as the failure of the passenger reconfirmation or the excessive number of passengers queuing before the security screening channel. Under the circumstances of such, the security staff will guide the passengers to the manual verification counter for identity verification. In this study, the manual verification counter is equipped with 1 to 1 face assisted verification system, of which the main devices are cameras and display screens.

2.2. System for 1 to 1 face verification
The self-service verification gate is deployed at the front of the security verification areas to verify whether the passengers, documents and flight ticket information are consistent and prevent unauthorized personnel from entering the security restricted areas. As shown in Figure 2, passengers only need to scan their ID cards in the card reading area. It is worth noting that the documents used by passengers in the area must be the second generation resident ID cards of the People’s Republic of China. By comparing the scene photos of passengers with the photos stored in the ID card, the system can carry out 1 to 1 identity verification, and check the corresponding flight ticket information of the passengers at the same time. In particular, the self-service verification gate is in the form of double gates. The design of double gates can effectively prevent passengers from tailing behind and reduce security risks.

![Figure 2. Diagram of the self-service verification gate](image)

The process of 1 to 1 self-service verification sets as follows:

1. Security staff guide the passengers to wait in the designated area and prepare their ID cards;
2. Passengers scan their ID cards in the card reading area, then the system reads and collects the identity information and the ID card photos, and matches the flight ticket information of the passengers. If the match is successful, the first gate will be opened; If the match fails, the gate does not open.
(3) Then the passenger passes through the first gate to the middle of the two gates. The camera captures the current passenger photo on the scene and automatically compares it with the pre-collected passenger ID card to verify whether the two are consistent. If the match is successful, the second door opens; If the comparison fails, it will alert the security staff to handle it.

(4) Passengers pass through the self-service verification gate, and the system will add "Verified" digital verification mark to the electronic information of the passenger.

2.3. System for 1 to N face recheck
The main purpose of the face recheck system is to avoid the entry of unauthenticated personnel and verify whether the passengers have been properly verified, thus enhancing the reliability of the security verification process. One advantage of the system is that the passenger doesn't need to present an ID card or a boarding pass in the face recheck area, the system automatically captures passenger's face information through the camera and matches the photo collected by the self-service verification gate to complete the face reconfirmation. The system for 1 to N face rechecking is deployed in front of the security screening channel with a single gate, as shown in the Figure 3.

![Diagram of the system for 1 to N face recheck](image)

Figure 3. Diagram of the system for 1 to N face recheck

The process of 1 to N face recheck is as follows:

1. Security staff guide the passengers to line up for face recheck before the 1 to N security check gate;
2. If the face recheck is successful, and the “Verified” digital verification mark of the passenger will be displayed on the screen terminal. At the same time, the “Rechecked” digital mark is added to the passenger's record, and the green light is on. The gate opens and the passenger enters the security screening channel.
3. If the face recheck fails, the passenger turns to the manual verification counter for check.
4. According to the number of passengers waiting to be checked, the security staff switches the check status of the face recheck gate by controlling the On/Suspend check buttons, controls the number of passengers entering, and gives the prompt of "waiting or pass through" on the display screen.

3. Empirical Test and analysis of the intelligent security verification process

3.1. Test environment settings
In order to verify the effectiveness of intelligent security verification scheme, we built a test platform in Hohhot Baita International Airport, with the purpose of verifying the effectiveness of the scheme in real situations. The tested face recognition baseline system was provided by Chongqing Institute of Green and Intelligent Technology, Chinese Academy of Sciences, which is a member of the Civil Aviation Anti-terrorism Technology Joint Laboratory. The verification area for testing contains four
security screening channels, three of which are equipped with 1 to N face recheck system, the rest channel is reserved for manual verification, and a 1 to 1 self-service verification system for passenger's identification and ticket are deployed in the front of the centralized verification area. The whole test lasted a week from Jan. 11, 2019 to Jan. 17, 2019.

3.2. Face recognition baseline system performance
To ensure that the baseline system of face recognition can meet the requirements of actual use, firstly, we tested the performance of face recognition baseline system on the LFW data set [11]. The said data set contains more than 13,000 face images collected from the web, is one of the most authoritative test databases in the field of face recognition. Each face has been labeled with the name of the person pictured. 1680 of the people pictured have two or more distinct photos in the data set. The results show that the recognition rate of baseline face recognition system can reach 99.82%. Secondly, we compared the performance of the face recognition baseline system with trained security inspectors. The process of face verification refers to giving a photo of the scene and an ID card to determine whether the two faces are the same person. The image data used for the test is a real security image collection database. It consists of 1000 real passenger sample pairs, and each sample pair contains a passenger photo and an ID card photo. In this data set, 50% of the face photos and ID card photos are not the same person. A total of 98 trained security inspectors participated in the test, of which 63 were identified with a correct rate of more than 80%; but only one security inspector had a correct rate of 97%, and the rest were below 95%. The accuracy of machine identification is above 97%, which is much higher than the average level of trained security inspectors. At the same time, the machine verification efficiency is higher than the manual verification, and the average duration of identifying a picture is less than 0.1 second, which can greatly improve the security check efficiency.

3.3. Passengers pass through rate analysis
We conducted a week of testing and statistics on the new security verification process. The results of the experiment are shown in Table 1. It shows that a total of 10,239 passengers passed through the 1 to 1 self-service verification gates within one week, of which 9,704 passengers successfully completed the 1 to N automatic face recheck, with an average ratio of 94.77%. It implies that a certain amount of the manual verification posts can be replaced by the intelligent verification system. The new security verification process using face recognition technology can magnificently reduce the labor intensity of security staff and improve the efficiency of security verification.

Table 1. Statistics of security verification process (a week)

|       | 1:1 face verification number | 1:N face recheck number | 1:N face recheck rate |
|-------|------------------------------|-------------------------|----------------------|
| Sun.  | 1541                         | 1490                    | 96.69%               |
| Mon.  | 1557                         | 1478                    | 94.93%               |
| Tues. | 1748                         | 1654                    | 94.62%               |
| Wed.  | 1421                         | 1315                    | 92.54%               |
| Thur. | 1456                         | 1360                    | 93.41%               |
| Fri.  | 1485                         | 1398                    | 94.14%               |
| Sat.  | 1031                         | 1009                    | 97.87%               |
| Total | 10239                        | 9704                    | 94.77%               |

In addition, we have analyzed the reasons why the passengers failed to pass the 1 to N recheck gate, mainly focusing on the following aspects: (1) The angle of the face captured by the camera is excessive; (2) The face was partially obscured, such as passengers with too long hair, wearing a hat
too low to cover the face or wearing sunglasses, etc.; (3) The face was not successfully detected due to strong backlighting.

3.4. Time efficiency analysis

Via the actual test, the average time spent by the passenger at the full manual verification counter is about 16 seconds. The test results are shown in Table 2, the average time of passing through the self-service verification gate is about 7 seconds, which can significantly improve the efficiency of identity verification. At present, the system is still in the trial phase. When the passenger is familiar with the process, the average time of passing through the system will be further shortened. The average time to pass the face recheck gate is about 3 seconds, passengers can complete their identity recheck at walking speed. The way of reconfirmation is non-perceptual and contactless. In this test, the average time spent by the passenger at the auxiliary verification counter equipped with 1 to 1 face assisted verification system is about 5 seconds.

| Verification System                          | Pass through mean time |
|---------------------------------------------|------------------------|
| 1 to 1 face verification gate (double gate)  | 7 s                    |
| 1 to N face recheck gate (single gate)      | 3 s                    |
| Manual verification counter equipped with   |                        |
| 1 to 1 face assisted verification system     | 5 s                    |
| Full manual verification counter             | 16 s                   |

3.5. Comparative analysis of the new process and the original security mode

Table 3 shows the advantages and disadvantages of the two modes.

| Intelligent security verification process | Original security mode |
|------------------------------------------|------------------------|
| **Advantages:** The process is objective; can effectively reduce the risk caused by human factors; has high accuracy of verification; and can make up for the problems of missed inspection. | **Disadvantages:** The verification work mainly relies on subjective judgment of security staff; and the verification quality is susceptible to the status and capabilities of security staff. |
| **Advantages:** Cost effectiveness, complete the collection of passenger's information through the camera, and enough for subsequent operations | **Disadvantages:** High labour costs, and excessive workload during passenger rush hours. |
| **Advantages:** High efficiency; the passenger only needs to show the ID card once; and the face recheck is non-perceptual and contactless, which significantly improves the passenger's satisfaction with security services. | **Disadvantages:** Passengers needs to show the ID card and boarding pass at security checkpoint at the same time, which leads to a long wait time and low efficiency. |
| **Disadvantages:** Special passengers cannot pass through self-service verification gates, such as passengers on wheelchairs. | **Advantages:** Security inspector can deal with abnormal situations flexibly and deal with emergencies quickly. |
| **Disadvantages:** It takes a certain amount of time to develop passenger habits. | **Advantages:** Passengers are already familiar with the original mode, and there are people who are not easy to accept the new mode. |
4. Conclusion
1. In general, the process proposed in this paper is feasible and can effectively improve the intelligent security level of the airport. It can effectively reduce the labor intensity of security verification staff, optimize the allocation of human resources, and improve the efficiency by reducing average time spending on manual ID checks at security checkpoint.

2. Moreover, the intelligent security verification system based on face recognition technology can avoid missed inspection caused by human factors. The intelligent security verification system can effectively prevent unauthorized passengers from entering the security screening areas or departure sterile area.

3. At the same time, the process is cost effectiveness, easy to adopt, operate and expand, and the pre-check of the background information before the security verification process will be considered in the future.

4. We believe that the identified hurdles are temporary and could be gradually solved by passengers’ behavior adaptation. The tangible solution is to provide proper guidance to passengers on site of the airport. Meanwhile, we intend to gradually build the awareness of general public of the new security verification model. With those efforts passengers would soon recognize the system’s efficiency and willing to adapt their behavior to facilitate the operation of the new model.

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