3J3-E-4-04

Identity Verification Using Face Recognition Improved by Managing Check-in Behavior of Event Attendees

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This paper proposes an identity-verification system using continuous face recognition improved by managing check-in behavior of event attendees such as facial directions and eye contact (eyes are open or closed). Identity-verification systems have been required to prevent illegal resale such as ticket scalping. The problem in verifying ticket holders is how to simultaneously verify identities efficiently and prevent individuals from impersonating others at a large-scale event at which tens of thousands of people participate. We previously developed Ticket ID system for identifying the purchaser and holder of a ticket. This system carries out face recognition after attendants check-in using their membership cards. The average face-recognition accuracy was 90%, and the average time for identity verification from check-in to admission was 7 seconds per person. The system was proven effective for preventing illegal resale by verifying attendees of large concerts; it has been used at more than 100 concerts. The problem with this system is regarding face-recognition accuracy. This can be mitigated by securing clear facial photos because face recognition fails when unclear facial photos are obtained, i.e., when event attendees have their eyes closed, are not looking directly forward, or have their faces covered with hair or items such as facemasks and mufflers. In this paper, we propose a system for securing facial photos of attendees directly facing a camera by leading them to scan their check-in codes on a code-reader placed close to the camera just before executing face recognition. The system also takes two photos of attendees with this one camera after an interval of about 0.5 seconds to obtain facial photos with their eyes open. The system achieved 93% face-recognition accuracy with an average time of 2.7 seconds per person for identity verification when it was used for verifying 1,547 attendees of a concert of a popular music singer. The system made it possible to complete identity verification with higher accuracy with shorter average time than Ticket ID system.

1. Introduction

Identity verification is required in an increasing number of situations. Let us take an example of a case in which many people are admitted to an event. It used to be that in such cases, having a document, such as a ticket or an attendance certificate, checked was sufficient to gain entry; the need for personal authentication was not seriously considered due to the limited amount of time for admitting all participants. Many events with high ticket prices had designated seating, so it was not necessary to assume that some tickets may have been counterfeit. However, the advent of Internet auctions in recent years has made it easier to buy and sell tickets at the individual level. This has resulted in an increase in illegal ticket scalping, i.e., tickets being purchased for resale purposes. Equity in ticket purchasing is required not only by ticket purchasers but also by event organizers and performers [Chapple 16]. Consequently, event organizers have had to deal with complaints about malicious acts by undesignated individuals who take advantage of fans by buying and selling tickets on the Internet. In many cases, therefore, any ticket buying and selling outside the normal sales channels is prohibited. Ticket-sales terms now often stipulate that tickets are invalid when people apply for them using a pseudonym or false name and/or false address or when they have been resold on an Internet auction or through a scalper. Illegally resold tickets have in fact been invalidated at amusement parks and concert halls [JE 15]. Verification has therefore become a more important social issue than ever before. The problem in verifying ticket holders is how to simultaneously verify identities efficiently and prevent individuals from impersonating others at a large-scale event at which tens of thousands of people participate. To solve this problem, we previously developed Ticket ID system that identifies the purchaser and holder of a ticket by using face-recognition software [Okumura 17]. Since the system was proven effective for preventing illegal resale by verifying attendees at large concerts of popular music singers and groups, they have been used at more than 100 concerts. However, it is necessary to improve face-recognition accuracy because face recognition fails when unclear facial photos are obtained, i.e., when event attendees have their eyes closed, not looking directly forward, or have their faces covered with hair or items such as facemasks and mufflers. We propose an identity-verification system for attendees of large-scale events using continuous face recognition improved by check-in behavior of event attendees such as facial directions and eye contact (eyes are open or closed).

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2. Ticket ID System Using Face Recognition

2.1 Outline of Ticket ID System

Thorough verification for preventing individuals from impersonating others is in a trade-off relationship with efficient verification. The problem in verifying ticket holders is how to simultaneously verify identities efficiently and prevent individuals from impersonating others at a large-scale event in which tens of thousands of people participate. The solution should be suitable within practical operation costs for various sized events held in various environments including open air. As a practical solution combining efficiency, scalability, and portability for a large-scale event, we developed Ticket ID system, which consists of two sub-systems, a one-stop face recognition system (one-stop system) and a check-in system [Okumura 17]. The one-stop system uses the high-speed and high-precision commercial face recognition product NeoFace [NEC 17]. The one-stop system is implemented in a commercially available tablet terminal, and the recognition result is displayed with regard to the facial-photo information of 100,000 people within about 0.5 seconds. The check-in system supports identity verification of attendees. A venue attendant checks in by placing his/her membership card on the card reader and initiates face recognition by the taking of his/her photos. The following steps make up the ticket-verification procedure from ticket application to admission [Okumura 17]:

Step 1: Tickets to popular events are often sold on a lottery basis at fan clubs or other organizations where membership is registered. Individuals applying for tickets register their membership information as well as their facial photos. In the same way for an ordinary ID photo, the registered facial photo is a clearly visible frontal photo taken against a plain background. The face must not be obstructed by a hat, sunglasses, facemask, muffler, or long hair.

Step 2: Event organizers notify ticket winners, i.e., successful applicants that have been selected.

Step 3: On the day of the event, venue attendants receive membership cards from attendees, and use a card reader to verify that attendants entering the venue are successful applicants at the event venue, as shown in Fig. 3.

Step 4: The attendants use the one-stop system to confirm that the photo taken at the time of application and the collation photo show the same person. The attendants explain the verification through face recognition to the attendees and instruct them where to stand in front of the terminal. Then, they execute the face-recognition process using the terminal to confirm the attendees are those who applied for the tickets.

Step 5: The admission procedure is carried out in accordance with the face-authentication results.

2.2 Problems with One-stop System

The average time for identity verification from check-in to entry admission was 7 seconds per person, and the average accuracy of face recognition was 90%. It is necessary to improve face-recognition accuracy by securing clear facial photos because face recognition fails when unclear facial photos are obtained, i.e., when event attendees have their eyes closed, are not looking directly forward, or have their faces covered with hair or items such as facemasks and mufflers. When face recognition fails, venue attendants have to verify attendees carefully by direct visual inspection. This increases the mental and physical burden on attendants, which makes attendees have an unreliable impression of the system. When face-recognition accuracy is 90%, two attendees are successively verified without face recognition failure with a probability of 81%. This means that 19% of attendees may experience face-recognition failure or observe it in front of them. Improving face-recognition accuracy is critical for decreasing attendants' stress and attendees' waiting time.

3. Continuous-Face-Recognition System

3.1 Managing Check-in Behavior of Attendees

We propose an identity-verification system for attendees of large-scale events using continuous face recognition improved by managing check-in behavior of the attendees. The proposed system enables attendees to check in themselves (check-in doers are not attendants, but attendees). While the previous system is equipped with a card reader, the proposed system verifies attendees with a QR code reader set up at the same position for recognizing faces of attendees standing still in front of a venue attendant, as shown in Fig. 4. Managing facial directions and eye contact are two major issues regarding facial recognition. The proposed system addresses these issues with the following methods:

1) Managing facial direction

The proposed system secures facial photos of attendees directly facing a camera by leading them to scan their QR codes just before executing face recognition. We found most people spontaneously look at the code-reader, i.e., turn their faces to the reader during check-in. The face-recognition camera of the proposed system is placed at the same position as the code-reader, as shown in Fig. 4, which makes it possible to take an attendee's photo when directly facing the camera when the photo is taken just after check-in.

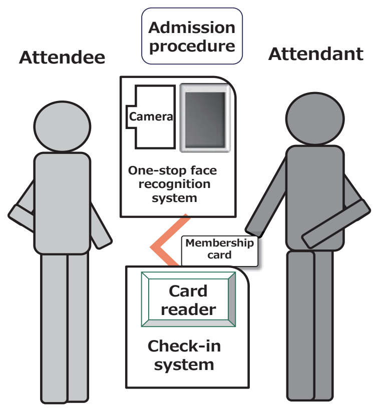

Fig. 3 One-stop face-recognition system

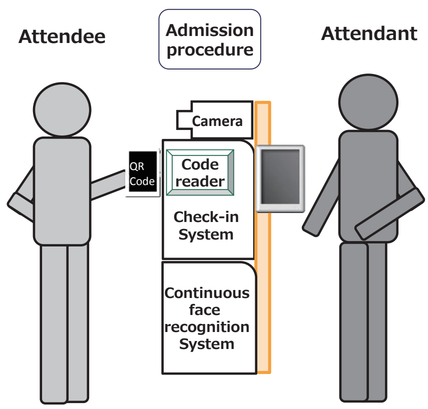

Fig. 4 Continuous face-recognition system

2) Managing eye contact

The proposed system uses a continuous-face-recognition system for accepting two photos of attendees successively taken with a single camera after an interval of 0.5 seconds to obtain facial photos with their eyes open. Few people spontaneously keep their eyes closed longer than 0.5 seconds because human blink duration is on average between 0.1 and 0.4 seconds [Bentivoglio 97]. Few people spontaneously blink twice in 0.5 seconds because human blink rate is between 7 and 17 per minute [Nosch 16]. It is possible to manage eye contact of attendees when we take the first photo at the same time of them scanning a QR code and then take the second photo after an interval of 0.5 seconds with a single camera.

3.2 Configuration of Proposed System

Figure 5 shows a configuration of the proposed system including event-attendee control platform and continuous-face-recognition system. The configuration is almost the same as that of the previous system [Okumura 17] except for a check-in doer and a QR code reader. While check-in doers of the previous system are attendants, those of the proposed system are attendees. While the previous system uses a card reader to scan membership cards, the proposed system uses a QR-code reader to scan tickets with QR codes. When attendees check in at a location that has the proposed system installed, they scan their QR-coded tickets. The attendee-management system provides the attendees the tickets in advance of the event day. Attendees can obtain tickets with QR codes with their smartphones. The ticket has the concert name, date and time, venue, QR code containing attendee's membership information, his/her name, seat number, registered photos, and so on.

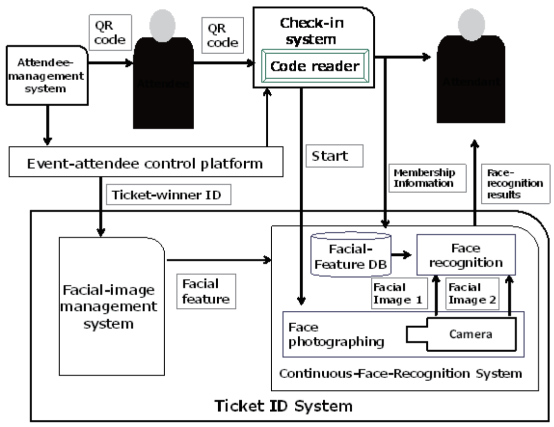

Fig. 5 Configuration of proposed system

3.3 Identity-Verification Procedure

An attendee's identity is verified with the procedure shown in Fig. 6. When attendees scan their QR codes, a check-in system performs ticket-winner check as well as showing the attendants the member information of the attendees, which is retrieved from the ticket-winner database with search keys of membership numbers obtained through a QR code reader. Scanning a QR code automatically activates continuous face recognition by taking two photos of the attendee after an interval of 0.5 seconds. When either photo is verified with the registered photo of the attendee, face recognition is successful. When attendees are ticket winners and face recognition is successful, the verification is successful. Otherwise, verification fails.

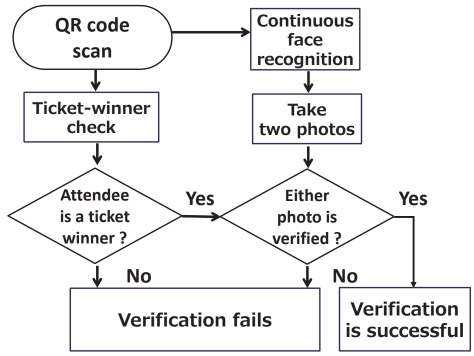

Fig. 6 Flowchart of verification

3.4 Operational Steps

The proposed system has the following operational steps from ticket application before the event day to admission on the event day:

Step 1: Ticket application is the same as that of the one-stop face-recognition system described in Section 2.1.

Step 2: Event organizers notify ticket winners, i.e., successful applicants that have been selected. They can obtain attendee's tickets including their QR codes and registered facial photos.

Step 3: At the check-in site on the event day, attendees scan their QR codes with the code reader according to attendant's instruction.

Step 4: Attendants can confirm that attendees are successful applicants who applied for the tickets.

Step 5: If identity is verified, the attendee is admitted entry. Otherwise, identity is verified by an attendant with direct visual inspection of the facial photo on the ticket.

4. Demonstration of Proposed System

4.1 Results

Six sets of the proposed system were used for a popular concert on November 17, 2018 in Tottori prefecture, Japan. Face recognition was carried out for 1,547 attendees. Face-recognition accuracy was 93%, and identity-verification time was 2.7 seconds on average in cases in which face recognition was not successful. No cases of attendees impersonating others were reported for the concert. The false reject rate (FRR) was 7% and the false accept rate (FAR) was 0%. There were two reasons for recognition failure: The first was that faces of incorrect attendees were detected when photos contained other attendees behind the correct attendee. The second was that the attendees had their faces covered with hair or items such as facemasks and mufflers. Failure was not observed due to the fact that attendees had their eyes closed or were not directly facing a camera.

4.2 Discussion

Table 1 compares the results of our previous and proposed systems. The average identity-verification time was 4.3 seconds shorter than that of the previous system because of changing check-in doers and improving face-recognition accuracy. The proposed system does not require handing over a membership card between attendants and attendees. The face-recognition accuracy of the proposed system was 3% higher than that of the previous system. This resulted in decreasing the number of direct visual inspections, which increases identity-verification time.

There was a problem with face detection in that faces of incorrect attendees were detected when photos contained other people behind an attendee. This can be solved by choosing the face with the largest face area among all the detected faces. Face recognition failed when attendees had their faces covered with hair or items. There were no cases in which attendees had their eyes closed or were not directly facing a camera in the two successive photos, i.e., in the first photo and second photo taken after 0.5 seconds. Managing facial direction and eye contact of attendees worked as expected. It is difficult to solve the problem of when the faces of attendees are covered with hair or items because there would be no differences between the first and second photos on the attendee's covered faces. The attendee’s cooperation is necessary for solving this problem.

Table 1 Results of our previous and proposed systems

	Previous system	Proposed system
Identity-verification time	7 seconds	2.7 seconds
Face-recognition accuracy	90%	93%
Check-in doer	Attendant	Attendee
Reasons for recognition failure	Attendees had their eyes closed.	
	Attendees were not directly facing camera.	
		Incorrect attendee’s faces were detected.
	Attendees had their faces covered with their hair or items.	

5. Future Issues

Faces of incorrect attendees were detected when they stood behind a correct attendee. This can be solved by choosing the face with the largest face area among all the detected faces. If this improvement does now work, we are preparing a partitioning screen to be placed behind the correct attendee to prevent incorrect attendees from being photographed.

The largest obstacle remaining to improving face-recognition accuracy is that of covered faces. This problem could be solved with attendee’s cooperation. We have been developing an identity-verification system using face recognition from selfies taken by attendees with their smartphone cameras [Okumura 18]. Self-photographing is regarded as helpful for securing clear facial photos because attendees can control intrinsic parameters such as their expressions, facial hair, and facial directions. We are planning to use of this system with the proposed system for solving the problem of covered faces.

The proposed system has been widely reported in the mass media. The system is highly regarded from reviews on the Internet [Hachima 18]. It was used to carry out face recognition for more than 100,000 attendees in 2018. Though no cases of attendees impersonating others were reported for any of these events, i.e., the FAR was 0%, the FAR should be more carefully examined from the view-point of preventing impersonation. It is necessary to evaluate the robustness against impersonation with pseudo attack tests. These tests should include disguise and lookalike tests. A disguise test makes people’s facial appearances as similar to each other as possible by using facial paraphernalia such as facial hair, glasses, and makeup. A lookalike test is conducted for those, such as twins or similar looking siblings, with similar facial features. A disguise test will reveal considerable disguise methods and help in creating operational manuals for venue attendants to detect these methods. A lookalike test will disclose the technical limitations of current face-recognition methods and help in establishing next-generation technology.

6. Conclusion

We proposed an identity-verification system for attendees of large-scale events using continuous face recognition improved by managing check-in behavior of the attendees. The proposed system could secure facial photos of attendees directly facing a camera by leading them to scan their QR codes on a QR-code reader placed close to the camera just before executing face recognition. The system took two photos of attendees with this one single camera after an interval of 0.5 seconds to obtain facial photos with their eyes open. The system achieved 93% face-recognition accuracy with an average identity-verification time of 2.7 seconds per person when it was used for verifying 1,547 attendees at a concert of a popular music singer. The system made it possible to complete identity verification with higher accuracy with shorter average time than the previous system. We plan to improve our system to further streamline the verification procedure.

References

[Chapple 16] Chapple,J.: Ticket resale? NO, says Japanese music business (Aug. 23, 2016), available from < https://www.iq-mag.net/2016/08/ticket-resale-no-says-japanese-live-business-resaleno/#.W_01Jk8Un3g>.

[JE 15] JE fandom: Johnny’s Tracks Illegally Sold Tickets for Arashi’s Japonism Tour (Oct. 25, 2015), available from <https://jnewseng.wordpress.com/2015/10/25/johnnys-tracks-illegally-sold-tickets-for-arashis-japonism-tour/>.

[Okumura 17] Okumura, A., etc.: Identity Verification of Ticket Holders at Large-scale Events Using Face Recognition, *Journal of Information Processing*, Vol. 25, pp. 448-458 (Jun. 2017)

[NEC 17] NEC: Face Recognition, available from < https://www.nec.com/en/global/solutions/safety/face_recognition/index.html>.

[Bentivoglio 97] Bentivoglio AR, etc.: Analysis of blink rate patterns in normal subjects, Mov Disord. 12(6) pp1028-1034, (Nov. 1997)

[Nosch 16] Nosch DS, etc,: Relationship between Corneal Sensation, Blinking, and Tear Film Quality, Optom Vis Sci. ,93(5) pp471-481, (May. 2016)

[Okumura 18] Okumura, A., etc: Identity Verification for Attendees of Large-scale Events Using Face Recognition of Selfies Taken with Smartphone Cameras, *Journal of Information Processing*, Vol. 26, pp. 779-788 (Nov. 2018)

[Hachima 18] Hachima: Concerts of Hikaru Utada were successfully operated, available from < http://blog.esuteru.com/archives/9218587.html>. (Nov.2018) (in Japanese)