The World's Best Face Recognition System to Achieve Safety and Security in Our Society

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Abstract

Computerization and the consequent diffusion of network services have been increasing the need for biometrics year on year. Face recognition is a technology that imposes a low work load on users because it is based on natural authentication movements, such as viewing a camera. NEC Information and Media Processing Laboratories first joined the Facial Recognition Evaluation Program of the U.S. National Institute of Standards and Technology (NIST) in 2009.Top ranking in recognition accuracy and search speed tests was awarded in the three consecutive years; 2009, 2010 and 2013. This paper describes the NEC face recognition technologies that achieved the top ranking performances, and discusses the results achieved in the NIST evaluation program of 2013.

Keywords

face recognition, face detection, face feature point detection, face matching, biometrics

1. Introduction

The recent increase in crime and the computerization of society have been increasing opportunities to use personal identification. In situations involving national-level security such as immigration control and criminal investigations and also in personal-level security such as for computer and system logins, personal identification procedures are typically carried out by machines.

Since biometrics identifies individuals based on information proper to each person such as by physical and behavioral features, one of its advantages is that persons will be free from constrains such as the need to remember a password or to carry an IC card. Various biological features can be used, including facial characteristics, fingerprints and pupils. However, as shown in **Fig. 1**, the face recognition technology is seen to be advantageous due to such possibilities as; non-contact recognition, non-necessity for special tools, the confirmation of matched results may be performed by human operators.

NEC's Information and Media Processing Laboratories have been engaged in the R&D of face recognition technology for about 25 years with the aim of achieving a "high recognition accuracy," which is a key issue in the implementation of a secure and safe society (**Fig. 2**). The results are already deployed as various solutions that feature high accuracy, such as in the immigration control services of more than 20 countries worldwide.

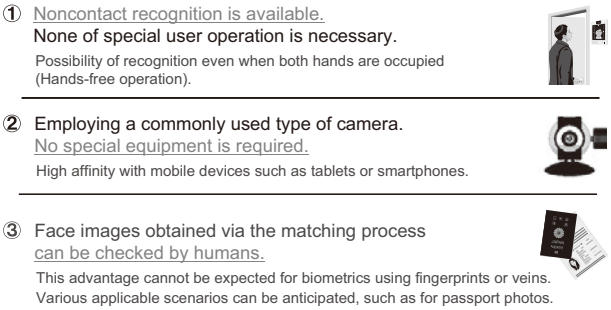

Fig. 1 Features of face recognition technology.

In section 2, we describe the face detection, feature extraction and face matching techniques proposed by NEC. In section 3 we report on evaluation results of the Face Recognition Vendor Test evaluation program conducted by the U.S. NIST. In section 4 we introduce a demonstration system, and in section 5 we draw conclusions.

2. Introducing the Face Recognition Technology

Fig. 3 shows the flow of face recognition processing[1]. The system first detects a face part in a captured image, and then extracts feature points in the face, including the pupils, subnasal points and mouth corners. Finally, the system matches the face images with the registered candidate image in order to calculate the degree of resemblance. It, then, identifies whether or not the person in the captured face image is the registered person. A certain threshold level is predetermined in the system, so that a face image marked with a higher degree than the threshold level is identified as the registered person, and one that is lower than the threshold level is identified as a person not registered.

The following subsections discuss details of each technology (**Fig. 4**).

(1) Face detection technology

For face detection, rectangular areas that match the face are extracted by sequentially searching face areas, starting from the edge of the image. The Generalized Learning Vector Quantization algorithm, which is based on the NEC-original Minimum Classification Error criterion, is used to recognize whether areas are of face areas or not. This procedure enables a fast and accurate face detection function.

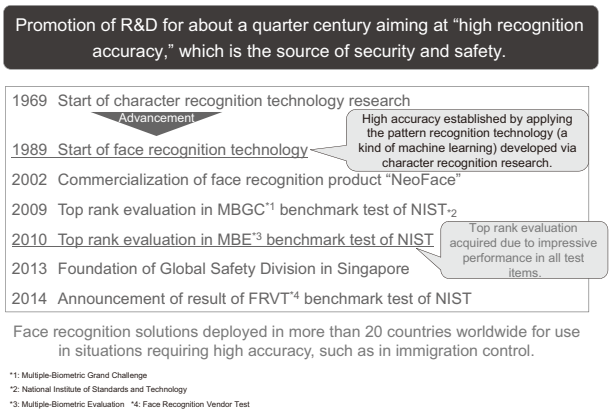

Fig. 2 History of the development of face recognition technology.

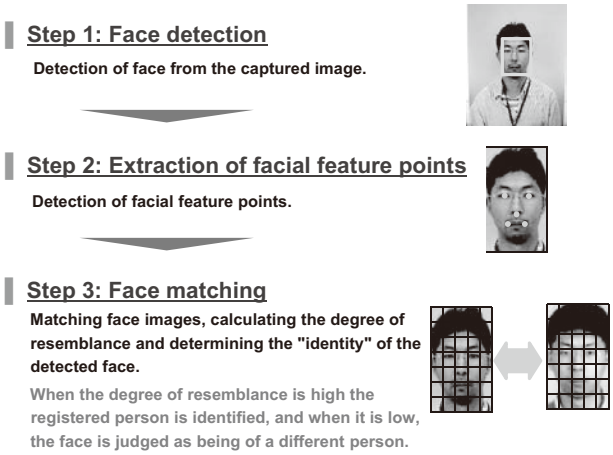

Fig. 3 Flow of face recognition processing.

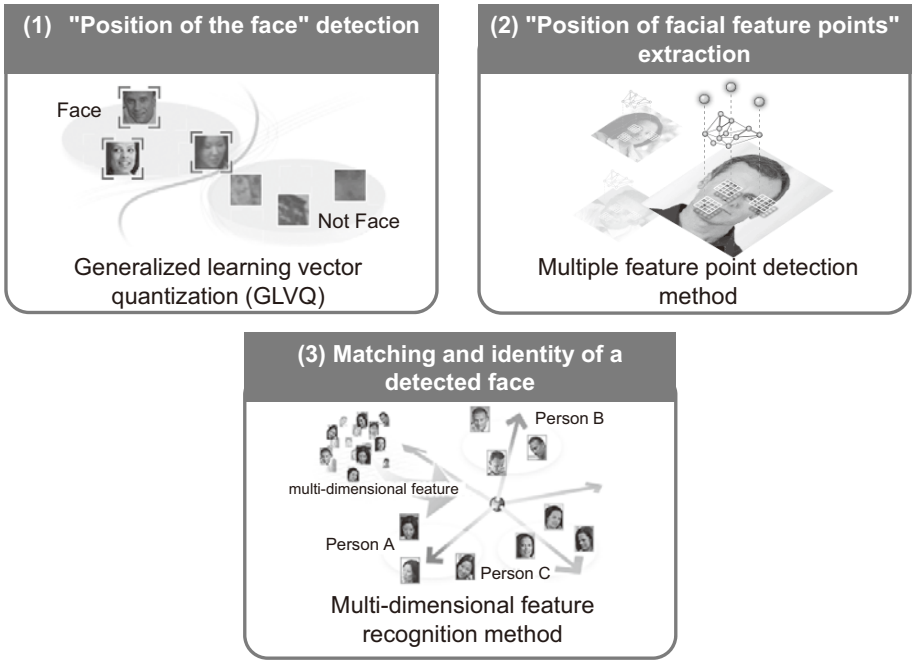

Fig.4 Three key methods supporting NEC's face recognition technology.

(2) Feature point extraction technology

The feature extraction technology finds the positions of face feature points such as a pupil, subnasal point and corner of the mouth. Brightness patterns around the feature are used to find the optimum position, while at the same time a facial shape model is used to constrain the alignment of features, thereby enabling precise estimation of their positions.

(3) Face matching technology

In order to identify whether or not the person with the captured face image is the registered person, the face matching process normalizes the face position using the obtained feature points. The captured face image and the candidate image are then collated. After extracting face features, such as the shapes and tilts of eyes and nose, the optimum feature for identifying the person is selected using the multi-dimensional feature recognition method. This procedure enables a robust personal identification solution that is unaffected by changes due to aging or other factors.

3. Results of Performance Evaluation by U.S. NIST

This section introduces the results of the face recognition performance evaluation carried out by the U.S. National Institute of Standards and Technology (NIST)[2]. The performance evaluation by NIST was started in 1993 and has become a benchmark test of worldwide authority that is employed even as a bid tender condition for immigration control systems (**Fig. 5**). NIST has already performed more than ten benchmark tests and challenging programs, in which major vendors and universities from many countries worldwide have participated. In the benchmark test, each participating organization sends its program and NIST evaluates it as a completely blind test. Reliance on the evaluation result is therefore extremely high. NEC joined the testing program in 2009 and has obtained the top ratings in all of the participated tests since then (2009, 2010 and 2013).

The results of the latest benchmark test held in 2013 were as follows. The test was called the Face Recognition Vendor Test (FRVT) 2013 and was under the sponsorship of the Federal Investigation Bureau (FBI) and Department of Homeland Security (DHS). Sixteen organizations participated, including major vendors and universities worldwide. The evaluation was started in August 2010, and the report was finally published in May 2014. The presupposed applications of the evaluation test item were for immigration control and forensic investigations.

Fig. 6 shows the results of the evaluation of the FRVT 2013. The graph shows the results of a collation of 160,000 persons. The X-axis represents the matching rate by the number of persons collated per second, and the Y-axis represents the matching accuracy by the search error rate, which is defined as 1-r assuming that "r" is the percentage that the correct person is recognized as at the top among the 160,000 registered persons. As seen in Fig. 6, NEC won the top ratings in both matching speed and accuracy by about twice the scores compared to the second-ranked organizations. The result showed a correct person recognition percentage of 97% and a matching rate of 3.02 million persons per second. The report published by NIST[2] assessed that NEC's algorithms have maintained the highest accuracy consecutively since 2010, that NEC's miss rate is the

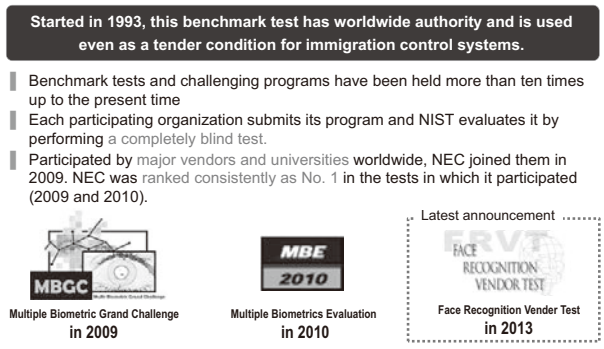

Fig. 5 Face recognition evaluation program of NIST.

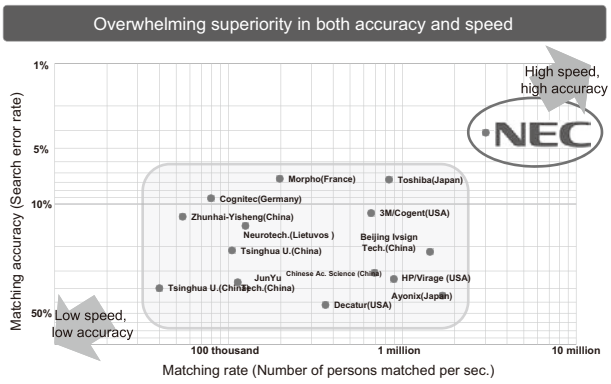

Fig. 6 Results of evaluation at FRVT 2013.

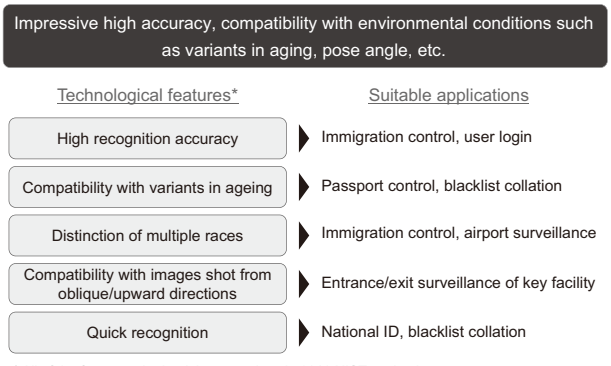

Fig. 7 Features of NEC's face recognition technology.

lowest of all the databases and that NEC's search error rate is less than half that of the competitor ranked closest to NEC.

Fig. 7 shows the details of our face recognition technology. In addition to the recognition performance and the speed described in Fig. 5, NEC has obtained top ratings in many items. These include: face variants due to aging, a capability that is required for recognition of a person from a passport photo, distinction of races that is required in global business operations and the recognition of face images from different pose angles that is required for entry/exit surveillance of a key facility, such as from the oblique or upward direction.

4. Introduction of a Demonstration System

To verify the algorithms ranked top by NIST in 2013, we loaded the latest algorithms in a notebook PC and measured the matching rate (**Fig. 8**). Using an NEC notebook PC incorporating Intel Core i7, we executed parallel processing of 8 threads of the 2.7 GHz CPU and achieved a matching rate of 33 million persons per second. As this figure means that 100 million people can be searched in about 3 seconds, the result is considered to be potentially capable of the application of large-scale person matching at a national level.

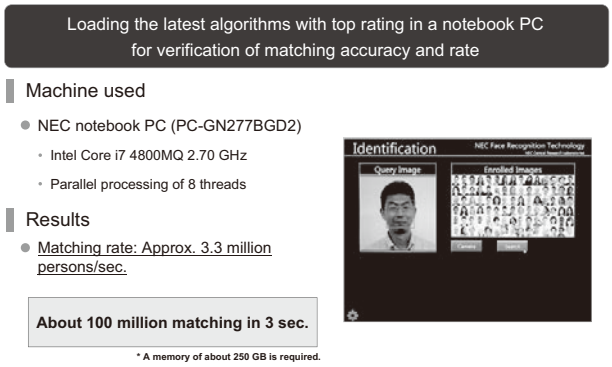

Fig. 8 Demonstration of the large-scale face image matching system.

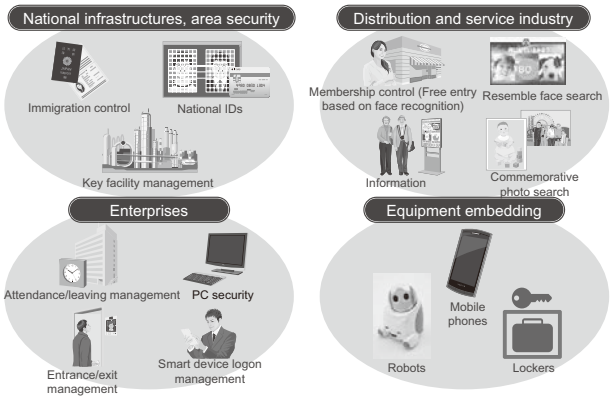

Fig. 9 Wide applications of face recognition technology.

5. Conclusion

In this paper, we describe NEC's face recognition by focusing on its technological aspects. Face recognition technology is applied in various scenarios from national infrastructures and security issues to equipment embedding services (**Fig. 9**). At NEC Information and Media Processing Laboratories, we set a high recognition performance as a key requirement and we are tackling the core technologies of the safety business in order to accelerate the development of solutions. We are doing this by targeting; 1) advanced technologies that can withstand larger scale and more mission-critical tasks; and 2) implementation of more advanced technologies that may be applied in more varied situations.

* Intel Core is a trademark of Intel Corporation in the U.S. and other countries.

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