IPC Face Recognition Technology White Paper

White Paper by Dahua Technology

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1 Foreword

In recent years, face recognition technology has become one of the most important biometric recognition technologies, integrating many professional technologies such as video image processing technology, AI (including machine learning etc.), big data and cloud computing. It is a jewel in the AI flied. With the rapid development of industrialization in the AI industry, innovation and breakthrough in the face recognition technology will certainly lead to explosive growth in its industry applications.

At present, the AI technology has broad application prospects in security, education, finance, commerce and other fields. AI is the core and foundation of the next technological revolution. It is not a separate industry. The strong radiation power and the spillover effect of AI contribute to its integration with many traditional industries and accelerate interconnection and intelligence of traditional industries, speeding up smart city construction in China. With the growth of deep learning algorithm and increase in the accuracy of AI recognition technology, AI is expected to contribute in crime prevention, city security, and valuable changes in schools, offices and public places.

2 Principle of Face Recognition Algorithm

2.1 Algorithm Module

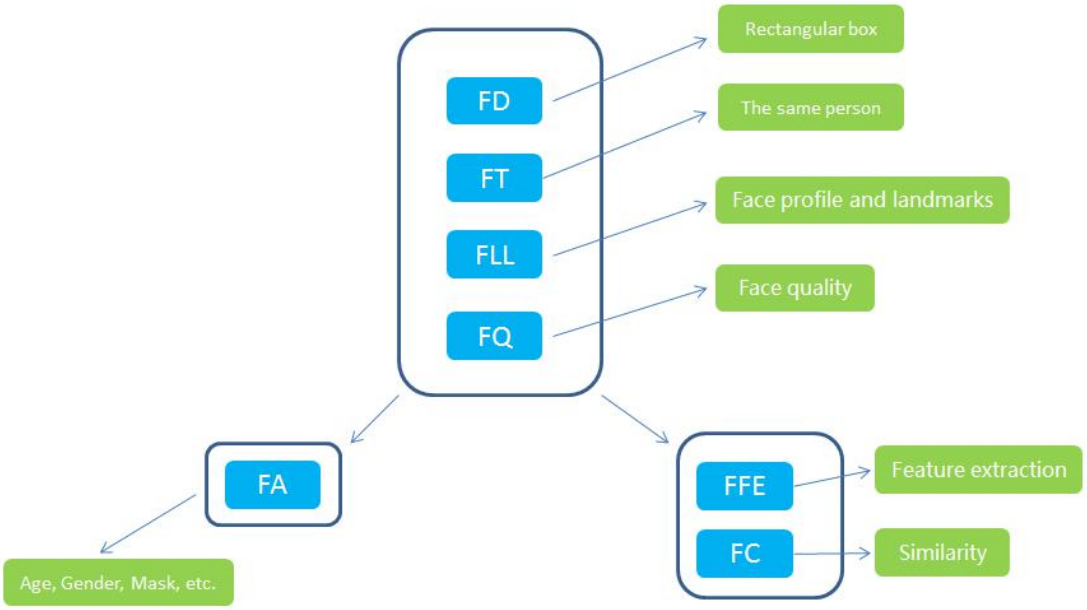

Figure 1 Face Algorithm Module

Face algorithm is divided into three parts:

- Face snapshot: Detection, tracking, landmarks alignment, and face selection. The overall aim is to find a human face from one or more images, or video sequences for recognition and analysis.
- Face feature extraction and comparison: Extract and compare face attributes. This step is commonly referred to as face recognition.
- Face attribute analysis: Recognize face attributes (gender, age, masks, glasses, beard, expression, etc. This step is called face attribute recognition.

2.2 Algorithm Process

Figure 2 displays the face algorithm flowchart in face recognition:

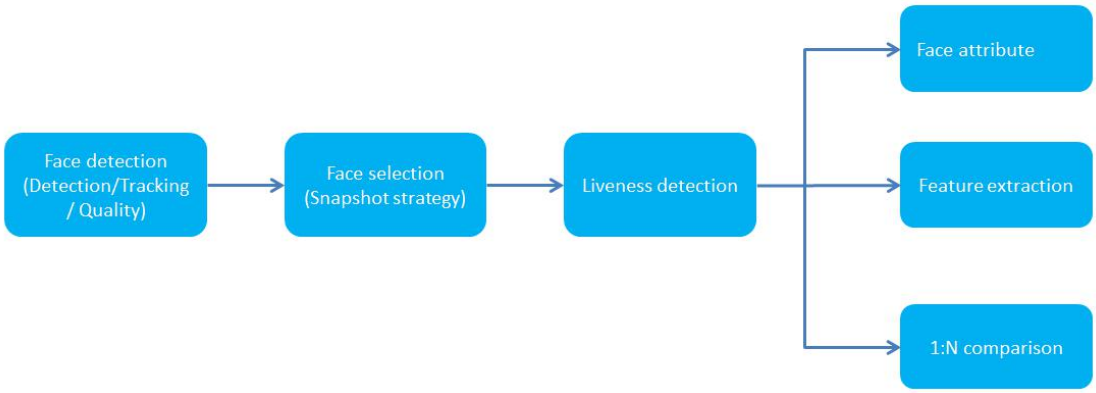

Figure 2 Face Algorithm Flowcharts

The face detection module detects target face position using a deep learning model and starts tracking and quality estimation correspondingly. The face image that users need is preferentially selected considering the selection strategy and quality estimation. The liveness detection module works to determine the origin of the face picture is a real human or a human's photo. Finally, to recognize and analysis the face on that picture, attribute recognition, feature extraction and matching with gallery will be done.

2.3 Face Snapshot

Face detection is a computer technology wherein location and size of faces are detected in any digital images. With this technology, face (2D or 3D) location, size and other information can be detected, and other objects such as building, tree and body will be omitted.

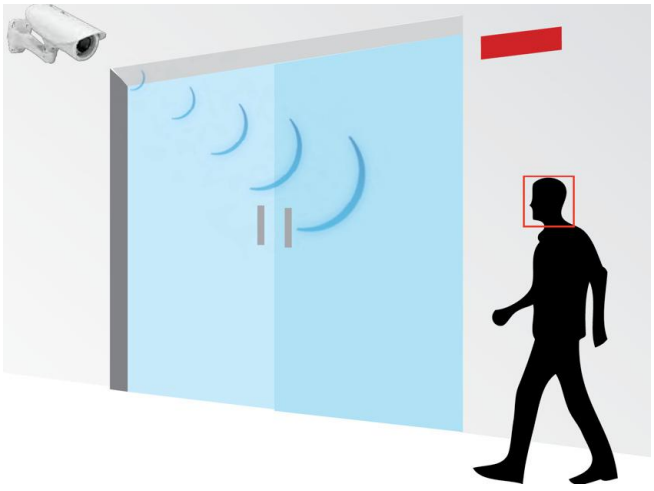

Figure 3 Face Detection

Face detection is an important part of the face recognition system. The advantages and

disadvantages of the face detection algorithm depend on two factors:

- Time-consumption: The time-consumption of face detection relies on the hardware platform, while a more effective algorithm can be designed for the specific hardware. With the same algorithm effect and fixed hardware platform, less time consumption can reduce product cost. Due to the restrictions on power consumption and hardware capability, a simplified algorithm is often used to realize faster detection on mobile platform with negligible reduction of the detection effect.
- Detection precision: When the lower limit of detection scale of face is determined, the detection precision depends on the detection rate (or recall rate) and the false detection rate. The face detection algorithm is usually suitable for faces under complicated environmental conditions such as strong light, weak light, dark night and others. Front face, profile face and other poses can be detected with this algorithm.

Face tracking connects faces of the same person between continuous video frames. According to the face position detected by face detection or forecasted by face tracking, each face in current frame would be bound to one certain face in last frame for they belong to the same person. Thus, a person's face trace in time sequence will be identified and marked with a unique ID.

Face tracking is an important part of the face recognition system, which provides ID information for subsequent face recognition. The evaluation measures for face tracking are tracking accuracy and tracking time.

- The tracking accuracy: depends on the correct rate of tracking, that's the proportion of the number of correctly tracked faces to total number of faces.
- Tracking time: The target tracking time is an important indicator to determine whether a tracking algorithm can be used in commerce, especially in video surveillance where algorithm results need to be real time.

Dahua face detection and tracking algorithms are suitable for application scenarios with different flow densities, such as a scenario with low density of 16 faces, or a scenario with high

density of 64 faces. Dahua face detection and tracking algorithms can be realized in real-time based on face only or combining face, head, shoulder and other information to improve the stability of face tracking. It also supports abnormal face detection, such as wearing masks, face occlusion, head bowed at 45°, profile face at ±90°, face in light or shadow, etc.

Face quality estimation and selection is a technical plan for sequential face recognition to promote recognition efficiency. It is a bridge to connect detection, tracking, landmarks location and attribute or ID recognition. Its main task is to select one or more high-quality faces for recognition from the face sequences of a person. For different tasks, it is divided into quality estimation for ID recognition or attributes recognition. Thus, the methods and evaluation measures to realize tasks are different. The face quality estimation is usually for ID recognition.

Face selection is mainly based on face quality. Face quality estimation mainly includes the following factors:

- Posture and angle
- Blurriness/Clarity
- Pixel size
- Light condition
- Face occlusion

Dahua IPC supports multiple selection strategies, such as real-time snapshot, quality selection, selecting snapshot.

- Real-time snapshot: Capture the first face image detected, With good real-time strategy;
- Priority snapshot: select the highest quality face image during the selection duration user set;
- Quality priority: Capture the first face image that reaches the quality threshold required by users. If all faces do not reach the quality threshold, select the highest quality face picture during the selection duration user set.

2.4 Liveness Detection

With the growth of face recognition technology, the gradual popularization of online payment and face recognition access system, and wide application in commerce, imitation of legal users' faces has become an important threat to the security of face recognition and verification system. It is easy to extensively copy faces through photos, videos and other face spoofing attacks. The current face recognition technology can identify face image but cannot accurately identify face authenticity. At present, an urgently needed solution for face recognition technology is ensuring system security by automatically and effectively identifying face image authenticity to prevent fraud and attack

Liveness detection refers to recognizing biological information on living body. Biological information is taken as biological features in order to distinguish photo, silicone, plastic and other inanimate objects. The existing liveness detection technologies include:

- Micro-texture: Face picture shows difference in texture detail on the real face through secondary acquisition and multiple acquisitions. However, this method is easy to be affected by light and resolution, and offers poor effect in case of video attacks.
- Motion information: Particular motion information in a face area is extracted from a video to determine face authenticity, conducting an interactive verification. Its disadvantage is poor user experience.
- Multi-spectrum: Face authenticity is determined based on difference in spectral reflectance of skin and other materials. It is an effective method, but needs strict acquisition conditions and higher hardware cost.
- Integration of multiple-feature and clues: One or more of the above methods are integrated for liveness detection. The detection rate is high, but this method needs longer processing time and strict hardware requirements.

2.5 Face Recognition

Face feature extraction is a face recognition technology (in a narrow sense) that extracts

features from face images for identity representation. Its two application modes are as follows:

- 1:1 Verification: Determine whether the two faces belong to the same person, and solve the "you are you" problem. For example, the comparison between real face and face photo on ID card in finance sector etc. The commonly used evaluation measure of face verification is VR@FAR (Verification Rate@False Acceptance rate). Set an acceptable false accept rate to select a threshold according to different application scenarios and take the verification rate of such threshold as the evaluation measure.
- 1:N Identification: Search in a specific registry to determine whether the captured face images belong to it. If yes, the corresponding enrolled target needs to be determined, solve the "who are you" problem. For example, static search and dynamic identification in security solutions. For static search, top-N recall rate is usually used as the evaluation indicator, while dynamic identification is similar to face verification. The verification rate and the false acceptance rate should be taken into consideration.

3 Highlights

3.1 Face Recognition Competition

In recent years, Dahua face recognition algorithms achieve excellent results in the industry, with awards including:

1) October, 2016, First in LFW (Labeled Faces in the Wild) Face Recognition Competition;

2) December, 2018, First in Driver Face Recognition in TMRI;

3) August, 2019, Silver Award in the First China Multimedia Information Recognition Technology Competition in Artificial Intelligence;

4) January, 2020, Top 5 in NIST (National Institute of Standards and Technology) Global Face Recognition Competition.

3.2 Face Self-adaptive Exposure

Face adaptive exposure technology detects targets based on AI algorithm and offers adaptive brightness control, to ensure optimal face snapshot and face recognition accuracy. This technology effectively enhances the adaptability of IPC scenario. It is suitable for scenarios with complicated light such as entrances, exits, and passages, reducing complexity of on-site installation and testing.

Figure 4 Face Self-adaptive Exposure

3.3 Mixed-exposure Technology

Traditional AI camera cannot realize optimal snapshot of face and vehicle (license plate) at night in a scenario with both people and vehicles. Face exposure parameter leads to fuzzy license plate and overexposure, while vehicle exposure parameter leads to dim face and detail loss. To obtain optimal face and vehicle (license plate) snapshot, two cameras are usually needed.

Dahua mixed-exposure technology can realize clear face and vehicle snapshot at night. It only uses one camera to obtain excellent face and vehicle (license plate) snapshot at night in a scenario with both people and vehicles accurately identifying people on the road.

Figure5 Mixed-exposure Technology

4 Summary

Dahua face technology and related products have been widely used in finance, security, public security, commerce, education, retail, and many other fields. With the launching of its products with face recognition technology, Dahua innovatively offers a variety of technical solutions to optimize face recognition and accelerate the development of the AI industry.