Mechanisms of face recognition system and its advantages

Philosophy

Face recognition (FR) is a biometric modality capable of uniquely identifying a human by his or her facial characteristics. Over the past decade, FR technology has been gaining a lot of popularity in the field of computer vision and pattern recognition. In fact, it is currently being implemented in many real-world applications such as secure authentication, access control, surveillance systems, e-payments or law enforcement.

Among all the different biometric solutions (e. g., voice, iris, fingerprint, signature) the main advantage of facial recognition is that no additional hardware apart from a camera is required. This makes it easy to implement on smart-phones and tablets, involving a non-intrusive acquisition process. In general, biometrics are conceived to be faster and more secure than traditional passwords, which are easy to steal and difficult to remember. In a survey conducted in 2017, 61% of 1, 000 US consumers stated that biometrics were easier than passwords. In addition, 70% of the citizens answered that biometrics were a faster way for authentication and 80% said that they would rather use fingerprint or face recognition for banking purposes.

Thanks to the development of artificial intelligence and neural networks, face recognition systems have reached very high identification rates in controlled scenarios. The evolution of graphics processing units (GPU’s) and the increase of annotated data have empowered deep FR models to learn more discriminative representations. As a result, face recognition has almost surpassed the human performance and is constantly improving the state of art. However, these capabilities get degraded under unconstrained environment conditions such as bad illumination, on-the-move acquisition, sided pose or low resolution. The 2018 Face Recognition Vendor Test (FVRT) showed a clear deterioration in the results of face recognition algorithms for the less-constrained/non-cooperative scenarios. All in all, biometric systems, like other applications of machine learning, are definitely affected by the quality of input data. That is why selecting images of the appropriate quality is key for any computer vision problem, including facial recognition systems.

Image Quality Assessment (IQA) for face recognition, also known as Face Image Quality Assessment (FIQA), measures the image degradation during its acquisition, compression, transmission, processing, and reproduction. Quality parameters for a facial recognition system are not only based on overall image measures (e. g., noise, contrast, lighting), but also in face specific measures (e. g., occlusions, pose, expression, local points). Evaluating quality information becomes very useful for many practical purposes. Quality metrics can be used at various steps of the FR pipeline to improve performance and usability in challenging conditions.

A typical face recognition system usually consists of three phases:

- Acquisition: collecting face images for either enrolling or verifying2/identifying3 a user. The former pictures are often called gallery, whereas the latter are referred to as probes.
- Template extraction: obtaining a feature representation from gallery or probe images to generate a face profile.
- Template comparison: matching face templates to check whether they belong to the same user or not.

On the one hand, acquisition phase is the best chance to re-capture a low-quality image potentially degrading the FR performance. A real-time feedback can provide the user essential information so quality standards during capture are fulfilled. For example, requiring to maintain a frontal pose, avoid shadows over the face or move closer/away from the camera. In this way, efficiency can be improved using FIQA to support decisions such as accept/reject a sample, reattempt a capture or declare a failure to acquire/enrol. Quality data can be also retained for later use in determining whether a gallery image should be replaced when the next sample is captured. This procedure has the risk of gallery contamination, but it can account for temporal variations such as facial ageing. In short, practices promoting the enrolment of high-quality pictures are critical to ensure sample consistency and improve overall matching performance.

On the other hand, the quality of a probe image during recognition (template extraction and comparison phases) is also employed to improve system performance. FIQA during verification can help to reduce false rejections. FR systems could discard a matching if the quality score is below a certain threshold, depending on the computation time required or the costs of a re-acquisition. In the case of identification, which is a computationally expensive process, it is a good idea to use quality assessment (less complex) to decrease computational load. Besides using FIQA as a filter for input images, quality assessment can be also applied to select appropriate image restoration techniques at a preprocessing stage. Illumination compensation is a good example of an image enhancement technique that has shown remarkable improvement in the recognition performance. In addition, FIQA can also be used in context-switching frameworks, i. e., dynamically select networks, classifiers, or matching metrics based on sample quality. Much literature reveals the benefits of context switching in a FR pipeline based on the information from FIQA algorithms.