A PhD proposal in Computer Vision and Pattern Recognition

3D-based Lighting Normalization for Reliable 2D Face Recognition

Background

Face recognition (FR) offers unmatched advantages as compared to other biometrics, such as easy access or needless explicit cooperation from users, and today, it has attained the reliability and the maturity required by real applications [1].With recent enormous developments, both academic and industrial research are focusing more and more on unconstrained real-scene face images in order to further extend the application field of FR while keeping its reliability as compared to constrained user cooperative conditions.

Reliable FR in unconstrained conditions needs to handle face images which are taken under various scenarios, notably with respect to uneven illumination environments, large facial expression changes, arbitrary head poses and ageing. In this thesis, the aim is to address one of these issues, *i.e.*, lighting condition changes.

Hypothesis under investigation and main aims

Lighting variations impinge upon many conventional FR algorithms which assume a normalized lighting condition because the lighting conditions may vary across not only the intensity and direction of the lighting sources, but also the color of light. The most challenging part of this thesis, which is also its attractiveness, lies in the realization of an illumination-invariant FR system which will integrate the lighting normalization module.

Specifically, the aim of this thesis is to raise some constraints on the existing 2D FR solutions thanks to 3D, thereby widening their range of application fields. These applications can include for instance FR dealing with non-ideal imaging environment where users may present their face not with a neutral lighting (e.g. side lighting), or even FR using images from video surveillance which can gather all the difficulties such as low resolution images, pose changes, lighting condition variations, occlusions, etc.

In this thesis, the candidate will investigate the possible contribution of 3-D to improve performances of authentication while keeping existing advantages of face recognition from 2-D images. It has been shown that using a 3D model of human face does improve 2D face recognition robustness to illumination and pose variation [2,3,4]. Our goal is to further explore the application and significance of 3D information for illumination processing.

Meanwhile, we propose to prioritize all these difficulties and investigate first the problem of lighting modeling by introducing 3D statistical model as a mathematical/physical explanation, then the focus will be upon the lighting normalization (i.e. delighting), ultimately the research is supposed to be finalized with illumination recovery (*i.e.* relighting), both delighting and relighting techniques could demonstrate their competitive ability to handle with FR suffering from lighting issues.

Research strategy

To cope with face lighting variations, the majority of techniques in the literature, such as our chromaticity invariant image [5], Self-Quotient Image [6] or the integrative preprocessing chain [7] build the image color formation principles based on 2D images and try to eliminate the lighting effect by introducing an illumination-related filter or searching for an illumination-invariant space. These approaches own a solid theoretical basis since they are derived from physical explanations of color formation which may be important to 3D extension.

Existing techniques using 3D information show their predominance against 2D based ones, including 3D morphable model [8], and its extensions, *e.g.*, spherical harmonic basis morphable model [9] or lighting effect decomposition

[10]. Meanwhile, most of these approaches are based on the assumption that facial skins deforms isometrically, which is not valid in case of extreme expressions such as mouth opening.

In this thesis, we want to explore a third strategy which aims at cancelling or defeating lighting variations in 2D facial images thanks to the use of a deformable 3D statistical face model [3,11]. The evident advantage of such an approach is that we keep all the valuable information even in the face mimic regions. For this purpose, our current extended 3D morphable model [12], which has been used successfully for face landmarking [13], pose correction and facial expression neutralization, can be an interesting entry point.

PhD fellowship award and eligibility

The fellowship provides a highly competitive monthly stipend and a conference and research related travel allowance to the awardee for a period of three years.

Qualified candidates have a master degree and are fully motivated by applied research work within the context of both academic research laboratory and leading international corporate research center. They should demonstrate outstanding qualities of academic performance, especially in mathematics (geometry, linear analysis, probability and statistics), computer vision, computer graphics and machine learning. Programming skills in C/C++ are required and knowledge on OpenGL is appreciated. Award Recipient will be selected based on their overall potential for research excellence.

About Morpho and ECL Liris

Morpho, a high-technology company in the Safran group, is one of the world's leading suppliers of identification, detection and e-document solutions. Morpho is specialized in personal rights and flow management applications, in particular based on biometrics, a sector in which it is the world leader, as well as secure terminals and smart cards. Morph's integrated systems and equipment are deployed worldwide and contribute to the safety and security of transportation, data, people and countries.

Ecole Centrale de Lyon (ECL) is a 150 years old top French grand Ecole of engineer having a tradition of excellence in research in the field of engineering. With roughly 100 permanent research staffers, Liris is an advanced research lab in information systems and image federating the research forces in computer science from four universities in Lyon, namely Université Claude Bernard, Université Lyon II Lumière, INSA de Lyon and ECL.

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