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Fast 3D face reconstruction based on uncalibrated photometric stereo

Yujuan Sun · Junyu Dong · Muwei Jian · Lin Qi

Abstract This paper proposes a fast algorithm for three-dimensional face reconstruction using uncalibrated Photometric Stereo. With a reference face model, lighting parameters are estimated from input face images lighted by unknown illumination, which can be used in classical photometric stereo to estimate surface normal and albedo. The estimated results are used in turn to refine the lighting parameters until an optimal estimation of the surface normal is achieved. Differing from traditional optimization algorithms, the iteration method used in this paper is a unified process thus results accurate lighting estimation. The proposed method relaxes lighting constraints and simplifies the image acquisition procedure. The reconstructed results tested on YaleB and BU3D databases show the effectiveness of our method.

Keywords Photometric stereo · Face surface normal · Face albedo · Lambertian model

1 Introduction

Three-dimensional (3D) face reconstruction is one of the most active research fields in computer vision. The geometrics and reflectance characteristics of the reconstructed human face are illumination invariant. With specularity and shading removed, the reconstructed 3D results are robust features of human faces, which can be used in practical applications [29].

However, classical photometric stereo (PS) requires many constraints to reconstruct the 3D shape and albedo of an object. For example, ref. [18, 27] reconstructed the 3D shape of an object from several input images, which were captured under a fixed camera and accurately recorded lighting directions. Recording the positions of light sources cannot always be easily achieved as in a laboratory, e.g. in a conference room or restaurant, lighting conditions are complex. Ref. [3, 8] overcame this drawback by using matrix decomposition and an

Y. Sun · J. Dong (✉) · L. Qi
Department of Computer Science and Technology, Ocean University of China, Qingdao, China
e-mail: dongjunyu@ouc.edu.cn

Y. Sun
Department of Information and Electrical Engineering, Ludong University, Yantai, China

M. Jian
Centre for Signal Processing, Department of Electronic and Information Engineering,
The Hong Kong Polytechnic University, Kowloon, Hong Kong

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