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Linearized Alternating Direction Method with Adaptive Penalty and Warm Starts for Fast Solving Transform Invariant Low-Rank Textures

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Abstract Transform invariant low-rank textures (TILT) is a novel and powerful tool that can effectively rectify a rich class of low-rank textures in 3D scenes from 2D images despite significant deformation and corruption. The existing algorithm for solving TILT is based on the alternating direction method. It suffers from high computational cost and is not theoretically guaranteed to converge to a correct solution to the inner loop. In this paper, we propose a novel algorithm to speed up solving TILT, with guaranteed convergence for the inner loop. Our method is based on the recently proposed linearized alternating direction method with adaptive penalty. To further reduce computation, warm starts are also introduced to initialize the variables better and cut the cost on singular value decomposition. Extensive experimental results on both synthetic and real data demonstrate that this new algorithm works much more efficiently and robustly than the existing algorithm. It could be at least *five times faster* than the previous method.

Keywords Transform invariant low-rank texutres · Linearized alternating direction method with adaptive penalty · Warm start · Singular value decomposition

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1 Introduction

Extracting invariants in images is a fundamental problem in computer vision. It is key to many vision tasks, such as 3D reconstruction, object recognition, and scene understanding. Most of the existing methods start from low level local features, such as SIFT points (Schindler et al. 2008), corners, edges, and small windows, which are inaccurate and unrobust. Recently, Zhang et al. (2012b) proposed a holistic method called the transform invariant low-rank textures (TILT) that can recover the deformation of a relatively large image patch so that the underlying textures become regular (see Figs. 1a, b). This method utilizes the global structure in the image patch, e.g. the regularity, such as symmetry, rectilinearity and repetition, that can be measured by low rankness, rather than the low level local features, hence can be very robust to significant deformation and corruption.

TILT has been applied to many vision tasks and been extended for many computer vision applications. For example, Zhang et al. (2011b) used TILT to correct lens distortion and do camera calibration, without detecting feature points and straight lines. Zhang et al. (2012a) applied TILT to rectify texts in natural scenes to improve text recognition on mobile phones. Zhao and Quan (2011)) proposed a method for detecting translational symmetry using TILT. Zhang et al. (2011a) further generalized the transforms allowed by TILT to polynomially parameterized ones so that the shape and pose of low rank textures on generalized cylindrical surfaces can be recovered. Mobahi et al. (2011) used the low rank textures recovered by TILT as the building block for modeling urban scenes and reconstructing the 3D structure.

TILT was inspired by Robust Alignment by Sparse and Low-rank decomposition (RASL) (Peng et al. 2010), which has been successfully applied to align faces and video frames. TILT and RASL share the same mathematical model, namely