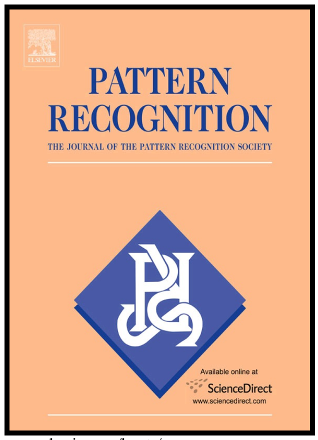
Author's Accepted Manuscript



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PII: S0031-3203(15)00360-X
DOI: http://dx.doi.org/10.1016/j.patcog.2015.09.029
Reference: PR5533

To appear in: *Pattern Recognition*

Received date: 22 November 2014
Revised date: 23 July 2015
Accepted date: 24 September 2015

Cite this article as: Jin-Gang Yu, Gui-Song Xia, Ashok Samal and Jinwen Tian, Globally Consistent Correspondence of Multiple Feature Sets Using, Proxima Gauss-Seidel Relaxation, *Pattern Recognitior* http://dx.doi.org/10.1016/j.patcog.2015.09.029

Globally Consistent Correspondence of Multiple Feature Sets Using Proximal Gauss-Seidel Relaxation

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Abstract

Feature correspondence between two or more images is a fundamental problem towards many computer vision applications. The case of correspondence between two images has been intensively studied, however, few works so far have been concerned with multi-image correspondence. In this paper, we address the problem of establishing a globally consistent correspondence among multiple (more than two) feature sets given the pairwise feature affinity information. Our main contribution is to propose a novel optimization framework for solving this problem based on the so-called Proximal Gauss-Seidel Relaxation (PGSR). The proposed method is distinguished from previous works mainly in three aspects: (1) it is more robust to noise and outliers; (2) its solution is based on convex relaxation and the principled PGSR method, which in general has convergence guarantee; (3) the scale of the problem in our method is linear with respect to the number of feature sets, making it computationally practical to be used in real-world applications. Experimental results both synthetic and real image datasets have demonstrated the effectiveness and superiority of the proposed method.

Keywords:
Feature correspondence, multiple feature set correspondence, permutation matrix, convex relaxation, proximal Gauss-Seidel method, graph matching

1. Introduction

Finding feature correspondence between different images is a fundamental problem in computer vision, which often serves as a preliminary ingredient in a wide range of applications, e.g. 3D reconstruction [1, 2], structure from motion [3], visual tracking [4], common pattern discovery [5], co-salient object segmentation [6, 7], just to name a few. However, pursuing reliable and efficient solutions to the feature correspondence is nontrivial, due to many challenging factors like matching ambiguity, sensitivity to noise and outliers, as well as the combinatorial property of the problem, *etc.*, and has long attracted quite a lot of research efforts in the community [8, 9].

The overwhelming majority of prior works on this topic to date have been devoted to feature correspondence between a pair of images [10, 11, 9, 12, 13, 14, 15]. Nevertheless, it is far more common in real-world applications that there are a collection of images available, rather than just two. In the task of 3D reconstruction [1, 2], for instance, one needs to align a set of images which reflect the same scene but are usually captured from different cameras or at different times, thereby under different viewpoints and lighting conditions. In the co-salient object segmentation problem [7], one may need to match the same object in different images, different object instances of the same object class, or even objects of different classes sharing certain common visual appearances. And in many multi-sensor-based applications [16, 17], a set of multi-modal images obtained from sensors of different modalities (e.g., infrared images, synthetic aperture radar images, remotely sensed orthohotographs, etc.) should be fused for further processing. In all these scenarios, it is commonly desired to establish a *globally consistent* correspondence across all the feature sets. For one thing, these applications mostly require associating those feature points which correspond to the same entity, so the correspondence essentially should be globally consistent. For another, recent studies have suggested that [18, 19, 20, 21, 22], incorporating global consistency in correspondence estimation can largely reduce matching ambiguity which may be caused by noise, outliers, similar visual patterns, *etc.*, thereby leading to remarkable improvement in matching robustness and accuracy. An intuitive illustration of globally consistent correspondence is given in Fig. 1.

In spite of its significance, the problem of estimating a globally consistent correspondence among multiple (more than two) feature sets has not been well explored yet, probably because of its high complexity as a combinatorially NP-hard problem. Most typically this task is addressed by relying on certain heuristics, for example, designating one of the feature sets as the reference and matching all the others to this reference

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