Towards a fast and reliable dense matching algorithm

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Abstract

In this paper, we present a dense matching algorithm which utilizes the corner and edge features of images to increase the reliability and to speed up the process of dense matching of two uncalibrated images. The major problem of classical area-based dense matching algorithms is the high computational time resulting from intensive correlation calculations for match candidates. Although some methods have attempted to integrate image feature information in the dense matching of uncalibrated images, most of these methods are not practical and are difficult to implement. This paper aims at designing a hybrid matching algorithm that preserves disparity continuity at the object continuous surfaces while discontinuity at object boundaries are treated differently in the matching process. In particular, both CPU-time and likelyhood of mismatches are reduced while the implementation is kept simple and straightforward.

keywords: dense matching, stereo vision

1 Introduction

The problem of establishing correspondences of pixels and other features across images represents a fundamental problem in computer vision. This is a very difficult task due to several reasons, in particular, not every feature in one image has a match in the other one. Although a large amount of work has been carried out over the past two decades on the matching problem [8, 3], dense matching remains unsolved and viewed as the bottleneck for many applications, such 3D reconstruction and view synthesis. Because stereo matching is inherently complicated and noise sensitive, classical approaches either were limited to a sparse matching or made additional assumptions. Sparse matching methods, also called feature-based methods, extract some selected features (e.g., corners, lines) in each image then attempt to establish the matching[11, 9]. The main drawback of these methods is the sparseness of the recovered information. On the other hand, dense matching aims at matching each and every pixel in one image with its correspondence pixel in the other image. Most of these methods are based on correlation techniques[2] to evaluate region similarities. However, because correlations are calculated intensively in the matching process, these methods are too slow. Constraints can be used to reduce the search for a match in the other image. The most popular one is the epipolar constraint resulting from the calculation of the fundamental matrix [6, 4]. Although this constraint reduces the search to one-dimension instead of two, the process is still very slow. The matching process can be made fast if two more constraints, the continuity and order constraints, can be enforced. In that case, the matching will be done pixel by pixel on each epipolar line, where each pixel's disparity will be dependent on its previous neighbor reducing the search to a minimum. However, these two constraints are not always satisfied in stereo images. In particular, the order might be violated with transparent(or overlapping) objects and the continuity does not hold at object physical boundaries. The order constraint is less important since it does not have a significant effect on the CPU-time of the whole matching process. On the other hand, the continuity constraint is far more important and, together with the epipolar constraint, is responsible for reducing most of the CPU-time. The satisfaction of the continuity/discontinuity constraints was addressed by several researchers. In particular, some recent energy-based methods[1, 10] solve the correspondence problem as a minimization problem that preserve discontinuities at object boundaries. However, the process is iterative and is far from straightforward to implement. Furtrhermore, the CPU-time was not addressed as part of the problem.

The method we present in this paper addresses the dense matching problem in the case of uncalibrated stereo images. We make use of the calculated epipolar geometry and the continuity constraints. The latter is used on homogeneous region while it is relaxed at region boundaries. Unlike energy-based methods, our method aims at decreasing CPU-time while it remains simple and straightforwards. Images are segmented into two sets of regions, the boundary regions and the nonboundary regions. The continuity constraint is enforced for the latter and relaxed for the former. In addi-