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Computing Multiple Image Motions

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Abstract

The computation of image motion for the purposes of determining egomotion is a challenging task as image motion includes discontinuities and multiple values mostly due to scene geometry, surface translucency and various photometric effects such as surface reflectance. We present algorithms for computing multiple image motions arising from occlusion and translucency which are capable of extracting the information-content of occlusion boundaries and distinguish between those and additive translucency phenomena. Sets of experimental results obtained on synthetic images are presented. These algorithms are based on recent theoretical results on occlusion and translucency in Fourier space.

1 Introduction

The importance of motion in image processing cannot be understated: in particular, approximations to image motion may be used to estimate 3D scene properties and motion parameters from a moving visual sensor, to perform motion segmentation, to compute the focus of expansion and time-to-collision, to perform motion-compensated image encoding, to compute stereo disparity and to measure biological parameters in medical imagery [1].

Based on recent theoretical developments in discontinuous motion, we devise multiple motion algorithms. We consider 1D and 2D signals, adopt a constant model of velocity and use a robust statistical procedure to extract multiple motions from local frequency spectra. The motion information provided by the algorithms includes single velocity, multiple (2) velocities, assessment of transparency versus occlusion, and upon occlusion events, the orientation of the occlusion boundary and the identification of the occluding signal.

1.1 Literature Survey

Many phenomena may cause multiple image motions. Occlusions, translucencies and various photometric effects such as specularities are among probable causes. In addition, occlusions contain valuable information concerning the geometry of the scene and may be used to decouple optical flow fields into their rotational and translational components, identify depth discontinuities, segment the scene with respect to motion and so on.

Computing multiple motions is a complex and rarely undertaken task. Indeed, most of the existing optical flow methods that have appeared in the literature make an explicit use of the optical flow constraint equation

$$\nabla \mathbf{I}^T \mathbf{v} - \mathbf{I}_t = 0, \qquad (1.1)$$

where $\nabla \mathbf{I} = (\mathbf{I}_x, \mathbf{I}_y)^T$ is the spatial intensity gradient and $\mathbf{v} = (u, v)^T$ is the image velocity. At motion discontinuities, where the information content of a signal mostly resides, the use of (1.1) becomes problematic as the single motion hypothesis is violated. Area-based and feature-based correlation techniques are equally sensitive to occlusion as local image structures and features appear and disappear from one image to the next. To further complicate matters, regularization techniques which impose a degree of continuity to optical flow are also clearly inadequate over occlusion boundaries. However, in the more recent research in optical flow, the non-linear, discontinuous and multiple-valued nature of image motion in the coordinates of the image plane has been recognized [1].

In order to allow multiple motion events in optical flow estimation processes, a number of strategies have been devised, such as strong intensity gradients acting as inhibitors of flow coherence [8] and robust estimators designed to capture dominant motions [3]. Other techniques such as clustering [9], superposed motion layers and distributions [10], parametric models of motion with discontinuous functions [4] and mixtures of probability densities [7] have appeared.