Anisotropic Diffusion by a Recursive Linear Convolving Method : Application to Space-time Segmentation and Pattern Recognition

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Abstract

This paper presents a recursive linear convolving method to performe anisotropic diffusion in images. The proposed method based on the linear filtering technique gives an useful evolving interface in boundary propagating. The novel approach is that there is not need to estimate local and global properties previously of the concerned propagating boundary, it making a fast algorithm. However these properties can be obtained directly from the evolving interface in our proposed method. Since the proposed method, formulated in the continuous space, can be implemented efficiently and with robustness in the discrete space, we propose practical applications like space-time segmentation and pattern recognition.

Keywords : isotropic diffusion, anisotropic diffusion, boundary propagating, segmentation, video sequence.

1. Introduction

It is well known that a simple way of modifying the linear scale-space paradigm represents an useful idea to solve isotropic diffusion problems. In this way, the importance of multiscale descriptions of images has been recognized. A clean formalism of scale-space filtering was introduced by Witkin [1], and further developed by Koenderink [2], Babaud [3], Yuille [4], and Hummel [5].

Traditionally, anisotropic diffusion has been formulated as a process that will mainly take place in the interior of regions, and it will not affect the region boundaries. It is intuitive that the success of the diffusion process is restricted by using a subclass of the monotonically decreasing functions [6].

Recently, anisotropic diffusion has been used to formulate propagating interfaces to design a general framework for modeling the evolution of boundaries. For that, the boundary value is formulated using initial value partial differential equations which describe interface motion.

Since the aim is to provide computational techniques for tracking moving interfaces. Initially deformable models « snakes » based on minimizing an energy along a curve were formulated [7]. A geometric alternative for the snake model was introduced in level set methods [8] in which an evolving curve was formulated. The method works on a fixed grid, usually the image pixels grid, and automatically handles changes in the topology of the evolving contour. The geodesic active contour model was born latter. It is both a geometric model as well as energy functional minimization. Although the geodesic active contour model has many advantages over the snake, its main drawback is its nonlinearity that results in inefficient implementations.

On the other hand, deformable models are used for the tasks of image segmentation, tracking of moving objects in video sequences [9][15], applications like $3D$ shape reconstruction in computer vision, applications in pattern recognition where each object can be described using a function named « descriptor of the region ».

In this work we introduce a recursive linear convolving method to perform anisotropic diffusion efficiently and with robustness in the discrete space. Consequently we provide a computational technique for tracking moving interfaces and any applications in computer vision.

This paper addresses the problem of simultaneously tracking non-rigid objects using a coupled front propagation model that integrates boundary–based and region based information.

This paper is organized as follows : Section 2 reminds the criteria for obtaining isotropic diffusion. In Section 3 we give a brief background on anisotropic diffusion and our recursive linear convolving method. In Section 4 we show the curve evolution as a profitable result of the recursive linear convolving method. In Section 5 and 6 we show the applications to space-time segmentation and pattern recognition respectively. Finally, in Section 7 the main conclusions of this work are shown.