Chapter 6

Object Segmentation Based on a Nonparametric Snake with Motion Prediction in Video

Sang-Myoung Ye
Sogang University, Korea

Rae-Hong Park
Sogang University, Korea

Dong-Kyu Lee
Sogang University, Korea

ABSTRACT

Object segmentation in video sequence is a basic and important task in video applications such as surveillance systems and video coding. Nonparametric snake algorithms for object segmentation have been proposed to overcome the drawback of conventional snake algorithms: the dependency on several parameters. In this chapter, a new object segmentation algorithm for video, based on a nonparametric snake model with motion prediction, is proposed. Object contour is initialized by using the mean absolute difference of intensity between input and previous frames. And in order to convert initial object contours into more exact object contours, the gradient vector flow snake is used. Finally object contour is predicted using a Kalman filter in successive frames. The proposed object segmentation method for video can provide more detailed and improved object segmentation results than the conventional methods. Various experimental results show the effectiveness of the proposed method in terms of the pixel-based quality measure and the computation time.

INTRODUCTION

The goal of object segmentation is to identify meaningful components in an image or video and to group the pixels belonging to such components (Zhang & Lu, 2001). Object segmentation, especially in video, is more challenging, because it is necessary to consider motion information for segmenting moving objects. Object segmentation in video has been used for various multimedia applications. In surveillance systems, object segmentation plays an essential role, which is implemented for automatic monitoring, recogni-

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tion and prediction of human. It is also used to achieve high compression performance in video coding. In addition, it is used in the areas of robotics and medical imaging (Blake & Isard, 1998).

In general, segmentation of moving objects can be categorized into motion-based and spatio-temporal methods (Zhang & Lu, 2001). Motion-based segmentation methods can be based on either motion representations or clustering. Traditional motion-based segmentation methods use only temporal (motion) information to deal with the scenes with rigid motion. On the other hand, spatio-temporal segmentation methods use both spatial and temporal information embedded in the sequence. They can reduce the drawbacks of an over-segmentation problem in image segmentation and overcome the noise-sensitivity and inaccuracy problems in motion-based segmentation (Zhang & Lu, 2001).

The spatio-temporal segmentation methods can be classified into two different methods: region-based and contour-based methods. The region-based methods have the advantage of the low computational cost, however, their results are sensitive to the parameter values selected. Among the contour-based methods, edge-based methods detect and combine the edges of an image to produce object contours. These methods have an advantage that they give a good performance. Another approach that has evolved from contour-based segmentation algorithms is active contours, so called snake-based segmentation algorithms (Jin et al., 2006; Kim, Alattar, & Jang, 2006; Kang, Kim, & Kweon, 2001; Hon, Yunmei, Huafeng, & Pengsheng, 2005).

Active contour algorithms have been widely used for object segmentation. Kass, Witkin, and Terzopoulos (1987) presented the active contour algorithm, in which parameterized contours are defined in an image domain. The active contour or snake algorithm is a segmentation process that utilizes energy-minimizing splines in the image with the internal forces coming from the curve itself and with external forces computed from image data. However, in the active contour algorithms, there are three major drawbacks: the dependency on many parameters, the very narrow capture range, and the difficulty in moving into boundary concavities.

A gradient vector flow (GVF) snake (Xu & Prince, 1998), with a high capability to deform contours into concave parts of the object, was addressed to reduce the sensitivity to contour initialization. Ozertem and Erdogmus (2007) proposed a nonparametric snake algorithm. They converted the problem of selecting unknown parameters of a snake into the problem of finding a good edge probability density estimate and removed the high dependency on parameter values of a snake model. Martin, Refregier, Galland, and Guerault (2006) presented the nonparametric statistical snake algorithm which is based on the minimum stochastic complexity. They minimized the energy of a snake based on the minimum stochastic complexity, in which they used a criterion that need not control any user-defined parameter. Abd-Almaged, Smith, and Ramadan (2003) and Rolfes and Rendas (2004) also proposed nonparametric snake algorithms. Abd-Almaged et al. (2003) presented a nonparametric technique to obtain statistical models based on the Bayesian decision. Rolfes and Rendas (2004) proposed a nonparametric snake algorithm based on mixtures of the probability distributions of the region nearby the contour.

In video, a number of snake algorithms have been widely used for contour extraction of moving objects. Park, Schoeflin, and Kim (2001) presented an object segmentation algorithm based on a snake using the gradient directional information. They included the gradient-directional information to the external image force in a snake using the gradient strength and direction of the image. Kim, Hong, and Lee (1999) proposed a segmentation algorithm for moving objects based on a snake using image flow. They presented a new contraction energy that is independent of the object shape and defined image flow as the

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