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Probabilistic Background Model by Density Forests for Tracking

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ABSTRACT

This paper proposes an approach for a robust tracking method to the objects intersection with appearances similar to a target object. The target is image sequences taken by a moving camera in this paper. Tracking methods using color information tend to track mistakenly a background region or an object with color similar to the target object since the proposed method is based on the particle filter. The method constructs the probabilistic background model by the histogram of the optical flow and defines the likelihood function so that the likelihood in the region of the target object may become large. This leads to increasing the accuracy of tracking. The probabilistic background model is made by the density forests. It can infer a probabilistic density fast. The proposed method can process faster than the authors' previous approach by introducing the density forests. Results are demonstrated by experiments using the real videos of outdoor scenes.

KEYWORDS

Background Model, Density Forests, Image Processing, Object Tracking, Particle Filter

INTRODUCTION

Tracking of a target object is an important research area in the field of computer vision. The tracking can be used for the traffic surveillance system, the behavior recognition, and so on. Tracking for such applications needs to track the target object in the situation where some objects with appearances similar to a target object exist around the target object.

Tracking methods based on the particle filter (PF) have been proposed recently (Del Bimbo & Dini, 2011; Enda, Fukui, Kurahashi, Takechi, & Iwahori, 2010; Isard & Blake, 1998; Khan, Balch, & Dellaert, 2004; Watanabe, Fukui, Takechi, Iwahori, & Woodham, 2012) for the robust tracking. A tracking method based on PF is robust to occlusion and noise. Appearance information, such as color and edge information of the object, is usually used for tracking. The methods using appearance information tend to fail in tracking the target object when similar objects come close to the target object, intersect with it or occlude the target object.

The tracking methods (Enda et al., 2010; Watanabe et al., 2012) improved so that the method may not track mistakenly a similar object around the target object as the target object. The method (Enda et al., 2010) introduced the likelihood of the velocity of the target object and the likelihood

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of the distance between the target object and moving objects which exist around the target object. The method uses images which are taken by a fixed camera and uses the background subtraction for improving the accuracy. The accuracy of tracking decreases when moving camera is used. The method (Watanabe et al., 2012) improved the tracking performance for such a case by introducing likelihood calculated by the probabilistic background model. The nonparametric Bayesian scheme is used for constructing the model. However, construction of the model is a heavy-loaded process. This is a big problem of the method.

In this paper, a new approach for the robust tracking is proposed. The method improves the tracking method (Watanabe et al., 2012). The method is also based on the particle filter. The likelihood is important for the particle filter based method for the better tracking performance. The proposed method uses the likelihood of the color, that of the velocity, that of the distance and that calculated by the probabilistic background model. In this paper, the probabilistic background model is constructed by the density forests (Criminisi, Shotton, & Konukoglu, 2012). The density forests can estimate the density distribution without the assumption of the number of distributions and can process fast. The proposed method can track faster than the approach (Watanabe et al., 2012) and the accuracy of the tracking of the proposed method is equal to or more than the approach (Watanabe et al., 2012). Results are demonstrated by experiments using real videos.

The construction of this paper is as follows: In the following section, the previous approach (Watanabe et al., 2012) is explained and the proposed background model constructed by the density forests is described in the next section. Then, the experimental results are shown. Finally, the paper is concluded.

TRACKING BASED ON PARTICLE FILTER

The proposed method improves the method (Watanabe et al., 2012) so as to track the target object at high speed. The method (Watanabe et al., 2012) is based on the particle filter. The tracking method is described in this section.

Outline of Proposed Method

The outline of the proposed method is as follows:

Step 0: Initialization
Step 1: Judging the situation under which the target object exists
Step 2: Prediction
Step 3: Calculating a weight of each particle after calculating likelihood
Step 4: Estimating the state variables by the weighted mean of the state variables of all particles
Step 5: Filtering by weighted resampling with replacement

The steps from STEP 1 to STEP 5 are processed at each frame.
The processes from STEP 0 to STEP 3 are described in the following subsections.

Initialization

The particle filter estimates the posterior probability by many particles. Each particle has state variables. The particle filter should initialize the state variables of each particle. The state variables are shown at first and the initialization process is described.

The state variables of i-th particle $c_t^{(i)}$ at a time t are defined as follows:

$$c_t^{(i)} = \left[x_t^{(i)}, y_t^{(i)}, u_t^{(i)}, v_t^{(i)}, w_t^{(i)}, h_t^{(i)}\right]^{\mathrm{T}} \left(i = 1,\ldots, N\right) \quad (1)$$