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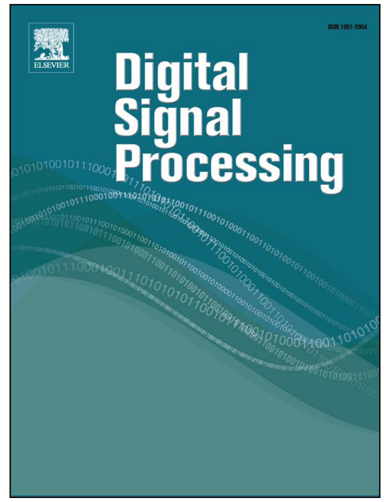

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Marjan Firouznia, Karim Faez, Hamidreza Amindavar, Javad Alikhani Koupaei, Pietro Pantano, Eleonora Bilotta

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Multi-step prediction method for robust object tracking

Marjan Firouznia[1*], Karim Faez[1], Hamidreza Amindavar[1], Javad Alikhani Koupaei[2], Pietro Pantano[3,4], Eleonora Bilotta[3,4]

[1] Electrical Engineering Department, Amirkabir University of Technology, Tehran, Iran
[2] Mathematics Department, Payamenoor University, P.O Box 19395-3697, Tehran, Iran
[3] Physics Department, University of Calabria, Via Pietro Bucci, 87036 Rende, Italy
[4] Psychology and Cognitive Science Laboratory, Physics Department, University of Calabria, 87036 Rende, Italy
[*] Corresponding author: Marjan.Abdechiri@aut.ac.ir.

Abstract

In this paper, multi-step ahead prediction method for object tracking based on chaos theory is introduced. The chaos theory is used to preserve the information of object's movement and to model uncertainty and nonlinearity of movement in video sequences. The methodology of the algorithm includes three steps. First, adaptive pseudo-orbit data assimilation is applied to estimate the next state by using the previous states of object. Second, the ensemble members of the state are generated to predict multi-step prediction. Then, the likelihood function of members selects candidate patch for target detection using color information. The algorithm significantly reduces the prediction error because of high-order dynamical information of motion and chaotic prediction. To verify the efficiency of the tracker, the tracking algorithm is compared with the stochastic and deterministic methods under two datasets. The results demonstrate that the chaotic-based tracker outperforms other state-of-the-art methods on the abrupt motion, occlusion, and out of view. The algorithm is about two times faster than the particle filter method while the error of particle filter is about two times more than the error of the chaotic-based tracking method.

Keywords: chaos theory, object tracking, multi-step ahead prediction, pseudo-orbit data assimilation, occlusion.

1. Introduction

Visual object tracking is a process to localize a target object in the image sequences. Object tracking is an active research topic in computer vision which is used in motion analysis, traffic monitoring as well as video analysis. A tracking system consists of three main components: visual representation, motion estimation, and object localization. Designing a stable and accurate system is a challenging task because of fast motion, low frame rate, and uncertain motion in the real world problems. The challenges are directly corresponding to motion estimation step of tracking system i.e., how to model the uncertainty and nonlinearity of object dynamics. To deal with the problems, a variety of parameter estimation methods have been proposed because the tracking system is defined as estimation and optimization problem. The tracking methods can be categorized into two groups; namely deterministic [1] and stochastic [2] methods.

The sequential methods estimate the next state based on Bayesian theory, which find a posterior distribution with the prior distribution such as Kalman filter [3, 4], particle filter [5, 6], and mean shift [7]. The mean shift algorithm exploits a region to maximize similarity measure iteratively. Obviously, the method is as a deterministic one. The algorithm may drift in the occlusions, in similar color distribution of foreground and background, and in long video sequences [8]. In contrast, stochastic methods employ statistical models for object tracking. Kalman filter is developed for linear and a Gaussian observational noise [9] as a sequential stochastic way, which cannot be applied to model nonlinear motion of object (rotation, translation, and irregular movement). The extended Kalman filter and unscented Kalman filter [10] reduced the assumptions of traditional Kalman filter for object tracking. The particle filter method can maintain the nonlinearity and uncertainty of the model evaluation and analysis steps in visual tracking [11]. In particle filter method, multimodal distribution may lead to noisy estimation of the target position [8] within abrupt motion and fast changes. In these cases, the particles are propagated in wrong direction which leads unsuitable PDF approximation of the target position.

Many extended particle filters have been proposed to improve the weaknesses of traditional particle filter in object tracking, including Gaussian particle filter [12] as a Gaussian approximation of posterior density, Iterative particle filter [13], and the extended Kalman-particle filter with LSSVR [14]. Hierarchical Kalman-particle filter introduced the coarse-to-fine strategy for global and local motion using Kalman and particle filter respectively [15]. Uncertainty between the static and dynamic components of state vector can be balanced by exploiting first order dynamic model using particle filter [15]. Particle filter can handle abrupt motion challenge using saliency map of current frame [16].

The chaos theory provides a useful bridge between deterministic and stochastic methods. In this paper, a new tracker using chaotic motion estimation is introduced. The proposed algorithm overcomes motion uncertainty with high dimensional

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