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Robust Discriminative Tracking via Structured Prior Regularization ☆

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Abstract

In this paper, we address the problem of tracking an object in a video sequence given its location in the first frame and no other information. Many existing discriminative tracking algorithms usually train a classifier in an on-line manner to separate the object of interest from the background. Slight inaccuracies in the tracking may result in incorrectly labelled training set, which can degrade the tracker. Although a number of approaches such as semi-supervised learning and multiple instance learning have been developed to address this problem, some critical issues still remain unsolved. This work aims to mitigate the shortcomings by exploiting a reliable generative model to support the discriminative learning process. A prior model based on a set of structured Dirichlet-multinomial distributions is proposed to preserve the target's structure information. This prior is then formulated as a regularization term in a training objective function, which casts the tracking task as a prior regularized semi-supervised learning problem. A multi-objective optimization method is developed to search for the solution, taking advantage of a decision maker inside to control the conflicts between different modules. The experiments show that this proposed method outperforms standard algorithms on challenging datasets. It is also demonstrated that the algorithm significantly mitigates the error accumulation effect.

Keywords: visual tracking, semi-supervised learning, multi-objective optimization, Random Forest

1. Introduction

Object tracking is a fundamental task in computer vision, which can be used in numerous different applications, including surveillance, autonomous vehicles, intelligent robots, augmented reality, and medical imaging. Although many approaches have been proposed in the literature, robust tracking still remains a challenging problem [1]. In real-world settings, objects are typically complex and difficult to track due to pose, rotation, illumination, blur, occlusion, abrupt motion and background clutter. Effectively modelling and maintaining target appearance are of prime importance for the success of a tracking algorithm, which has attracted much attention in recent years [2] [3] [4] [5] [6] [7] [8] [9] [10].

Typical discriminative tracking algorithms [11] [12] consist of a two-step "estimate-update" process [13]. First, a predefined appearance model is utilized to evaluate the likelihood in the current frame and a decision strategy is used to estimate the target's image position. Second, once the position is determined, new foreground/background information is extracted to update the appearance model.

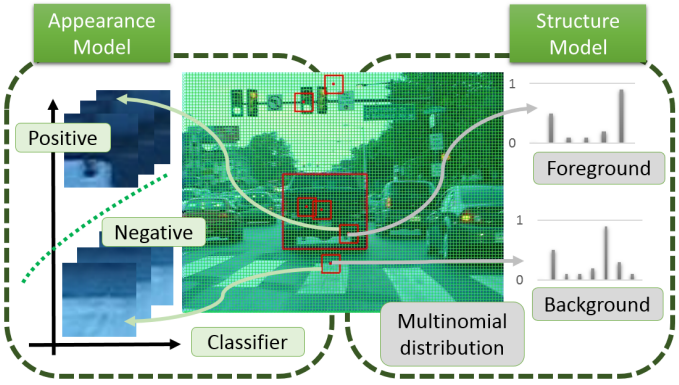

Figure 1: Left side: discriminative appearance model; Right side: generative structure model (image source: [16]).

A critical drawback of this mechanism is that the suboptimal estimation caused by noise will lead to inaccuracies in the update step, consequently degrading the model. An inaccurate model in turn may result in even worse estimation results [11]. Although some methods like multiple instance learning [11] [14] and semi-supervised learning [13] [15] have been proposed, accurate object tracking still remains a challenging issue.

In this paper, our motivation is to devise a new strategy based on reliable rules to update the model that minimizes error accumulation. The goal is to improve visual tracking robustness, especially to avoid drift. The key idea is

☆This paper has supplementary downloadable material available at http://www.ece.mcmaster.ca/~kiruba, provided by the author. The material includes one demo video with the tracking results discussed in the paper in standard avi format. The total size of the video is 391 MB. Contact yuy32@mcmaster.ca for further questions about this work.

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