

A Novel Probability Model for Background Maintenance and Subtraction

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Abstract

“Background maintenance and subtraction” is an important problem for many computer vision applications. This paper proposes a novel model for background. This model includes two components and it processes the video sequence at pixel level and frame level alternatively. The advantage of this model is that it can capture both the temporal and spatial context of the video sequence. At pixel level, we believe that any probability model for “pixel process” can be used, at frame level, we use Markov Random Field.

And for a particular application - video surveillance on freeway, we propose a new pixel level model-adaptive HMM. In our experiments about the video surveillance on freeway, the model can solve the problems encountered: bootstrapping, gradual change of illumination, and it can detect both moving vehicles and shadows.

1 Introduction

In many computer vision applications, one basic module is “Background subtraction” which subtracts the estimated background from current image to find those pixels to be processed further. Typically, these systems have one or several fixed cameras directed at the regions interested: freeways, parking lots or the scenes wanted to be rendered. For example, in video surveillance systems (e.a. VSAM [1]), this module can find moving vehicles and people that should be identified or tracked. In real-time rendering systems (e.a. Tele-immersion [2]), the module can find the objects whose depth should be re-estimated for rendering, and so on.

Background changes sometimes. In Figure 1, illumination changes may make the difference between background and shadow becomes less noticeable, as shown in the right image. In practical systems, the difficulty is not the “subtraction” itself, but estimation of the current background. We must adapt the background model to the change of background. This procedure is called Background Maintenance: “maintenance of background model- some representation of the background and its associated statistics” - Kentaro

Toyama [3]. Considering the variant cases [3] and subtle tradeoffs [4], background maintenance and subtraction is a hard problem. Several models have been proposed. We give a brief review of these models in next section.

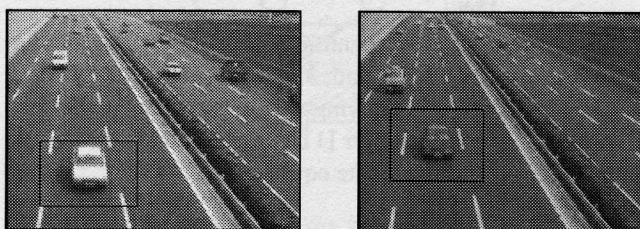


Figure 1: Freeway background varies with illumination.

In this paper, we propose a new model for background maintenance and subtraction. The model includes two components. The two components process the images at pixel level and frame level alternatively. The model is relatively general. Any probability model for pixel process [1] can be incorporated into our model as the pixel level component. At frame level, we use Markov Random Field (MRF). With this model, both temporal and spatial context is modelled explicitly. Specifically, we propose a new pixel level model - adaptive Hidden Markov Model (HMM). For HMM, both offline learning algorithm, which can be used for initialization, and online learning algorithm, which can be used for adaptation, are discussed. For MRF, we use Belief Propagation algorithm [5].

This paper is organized with following fashion. In section 2, we give a brief review of previous background models. In section 3, detail of our model and learning algorithm are described. Section 4 and 5 are our experiment results, discussions and future work.

2 Previous background models

Several models have been put forward for background maintenance and subtraction in the literature[1] [3] [6] [7] [8] [4]

