Int J Comput Vis (2013) 103:326–347
DOI 10.1007/s11263-013-0608-1

Training Effective Node Classifiers for Cascade Classification

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Received: 25 May 2011 / Accepted: 1 January 2013 / Published online: 24 January 2013

Abstract Cascade classifiers are widely used in real-time object detection. Different from conventional classifiers that are designed for a low overall classification error rate, a classifier in each node of the cascade is required to achieve an extremely high detection rate and moderate false positive rate. Although there are a few reported methods addressing this requirement in the context of object detection, there is no principled feature selection method that explicitly takes into account this asymmetric node learning objective. We provide such an algorithm here. We show that a special case of the biased minimax probability machine has the same formulation as the linear asymmetric classifier (LAC) of Wu et al. (linear asymmetric classifier for cascade detectors, 2005). We then design a new boosting algorithm that directly optimizes the cost function of LAC. The resulting totally-corrective boosting algorithm is implemented by the column generation technique in convex optimization. Experimental results on object detection verify the effectiveness of the proposed boosting algorithm as a node classifier in cascade object detection, and show performance better than that of the current state-of-the-art.

Keywords AdaBoost · Minimax probability machine · Cascade classifier · Object detection · Human detection

1 Introduction

Real-time object detection inherently involves searching a large number of candidate image regions for a small number of objects. Processing a single image, for example, can require the interrogation of well over a million scanned windows in order to uncover a single correct detection. This imbalance in the data has an impact on the way that detectors are applied, but also on the training process. This impact is reflected in the need to identify discriminative features from within a large over-complete feature set.

Cascade classifiers have been proposed as a potential solution to the problem of imbalance in the data (Viola and Jones 2004; Bi et al. 2006; Dundar and Bi 2007; Brubaker et al. 2008; Wu et al. 2008), and have received significant attention due to their speed and accuracy. In this work, we propose a principled method by which to train a *boosting*-based cascade of classifiers.

The boosting-based cascade approach to object detection was introduced by Viola and Jones (2004, 2002), and has received significant subsequent attention (Li and Zhang 2004; Pham and Cham 2007b; Pham et al. 2008; Paisitkriangkrai et al. 2008; Shen et al. 2008; Paisitkriangkrai et al. 2009). It also underpins the current state-of-the-art (Wu et al. 2005; Wu et al. 2008).

The Viola and Jones approach uses a cascade of increasingly complex classifiers, each of which aims to achieve the best possible classification accuracy while achieving an extremely low false negative rate. These classifiers can be seen as forming the nodes of a degenerate binary tree (see Fig. 1) whereby a negative result from any single such node classifier terminates the interrogation of the current patch. Viola and Jones use AdaBoost to train each node classifier in order to achieve the best possible classification accuracy. A low false negative rate is achieved by subsequently adjusting the decision threshold until the desired false negative rate is achieved. This process cannot be guaranteed to produce the best detection performance for a given false negative rate.

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