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Beyond Independence: An Extension of the A *Contrario* Decision Procedure

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Abstract The *a contrario* approach is a principled method for making algorithmic decisions that has been applied successfully to many tasks in image analysis. The method is based on a *background model* (or null hypothesis) for the image. This model relies on independence assumptions and characterizes images in which no detection should be made. It is often image dependent, relying on statistics gathered from the image, and therefore adaptive. In this paper we propose a generalization for background models which relaxes the independence assumption and instead uses image dependent second order properties. The second order properties are accounted for thanks to graphical models. The modified *a contrario* technique is applied to two tasks: line segment detection and part-based object detection, and its advantages are demonstrated. In particular, we show that the proposed method enables reasonably accurate prediction of the false detection rate with no need for training data.

Keywords A contrario decision · Object recognition · Significance test · Background model · Number of false alarms · Meaningful matches

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1 Introduction

Common algorithms in computer vision, such as, edge detection and object recognition, involve decisions. These decisions typically calculate some scalar function and test it against a threshold. The quality of the decision is usually very sensitive to the chosen function and the threshold value. A common approach to such decision procedures follows the Bayesian methodology; see, e.g., Weber et al. (2000), Konishi et al. (2003). The decision is optimized so that it minimizes a cost function related to two types of errors: false alarms and misses. Statistical models, required for this minimization, are usually learned in a training phase. Costly to collect and label, the training data often does not best represent the true distribution of the test data. Moreover, even if it does, the optimized parameters are best only on the average and are not necessarily optimal for the particular image at hand.

An alternative, general, non-Bayesian approach for decision making and parameter tuning, suggested several years ago (Desolneux et al. 2000, 2008), has already been applied successfully to diverse tasks; see e.g., edge detection (Desolneux et al. 2001), histogram mode selection (Desolneux et al. 2008), robust point matching (Moisan and Stival 2004) or local feature matching (Rabin et al. 2009). Denoted *a contrario*, this powerful methodology quantifies the Helmholtz principle that “we do not perceive any structure in a uniform random image” (Desolneux et al. 2008). See Fig. 1 for an illustration of this principle.

In *a contrario* decisions, the parameters (e.g., the thresholds) are set so that a decision algorithm would not accidentally detect too many visual events (such as edges, lines, familiar objects, etc.) in a “random” image. The random image and the implied false detection rate are specified by a probabilistic background model. Unlike a common approach in