Baum-Eagon inequality in probabilistic labeling problems

La disuguaglianza di Baum-Eagon nei problemi di labeling probabilistico

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Abstract: This work illustrates an approach to the study of labeling, aka "object classification". This kind of parallel computing problem well suites to AI applications (pattern recognition, edge detection, etc.) Our target consists in simplifying an overly computationally costly algorithm proposed by Faugeras and Berthod; using Baum-Eagon theorem, we obtained a reduced algorithm which produces results comparable with other more complex approaches.

Keywords: Labeling, Artificial Intelligence, Edge detection, Probabilistic algorithms, Pixel classification.

1 Introduction

Our work aims to study the possible applications of Baum-Eagon inequality [Baum and Eagon (1967)] to the "labeling" problems, which consist in assigning classes (labels) to objects. For example, let us consider an image whose included objects' contours we want to outline (*edge detection*). In this case, the objects are pixels of which the image is made of, and the labels (classes) assignable to every pixel can be "contour pixel", "not-contour pixel".

Many authors have faced this problem; in particular, Faugeras and Berthod (1981) require every object to be related with one or more neighbor ones. This situation can be represented by a graph, in which nodes are objects and edges represent existing relations between objects [Hummel and Zucker (1983)]. Such concept can be exemplified considering a phrase containing an ambiguous word: to get its meaning, it may suffice to understand the meaning of neighbor words (*context*). The fact that a word in the phrase allows to go back to the ambiguous word's meaning shows a certain relation between them. Generally, in a phrase the words nearest to the ambiguous one are those useful for its meaning's discovery.

More recently, some authors have faced this problem adopting different approaches. Frigessi and Green (2000) propose a non parametric method to estimate the potential interactions in a Markov Random Field; such method can be applied to some parts of a "biased" image taken from sensors subject to noise (e.g. from satellite). Kleinberg and Tardos (2002) deal with the so-called "metric labeling problem"; it consists in the control of a cost function $c(p, a)$, which represents the cost deriving from the assignment of a label a to an object p. The evaluation of such a cost comes from a likelihood estimate (of having the label a assigned to the object p) starting from an initial observation. To $c(p, a)$ is added the cost bound to a weight measuring, in some way, the "influence" brought to the object p by other objects related to it (in the case of an image, the influence of neighbor