

Chapter 3

Application of Improved Illumination Invariance Algorithm in Building Detection

ABSTRACT

The problem of edge-based classification of natural video sequences containing buildings and captured under changing lighting conditions is addressed. The introduced approach is derived from two empiric observations: In static regions the likelihood of finding features that match the patterns of “buildings” is high because buildings are rigid static objects, and misclassification can be reduced by filtering out image regions changing or deforming in time. These regions may contain objects semantically different to buildings but with a highly similar edge distribution (e.g., high frequency of vertical and horizontal edges). Using these observations, a strategy is devised in which a fuzzy rule-based classification technique is combined with a method for changing region detection in outdoor scenes. The efficiency of the described techniques is implemented and tested with sequences showing changes in the lighting conditions.

1. INTRODUCTION

The classification of “building images,” or images in which a substantial part of the scene consists of man-made buildings, is an important problem in image processing. It has applications in several areas of technology including remote sensing, pattern recognition and automatic annotation of video for categorization and retrieval. The work leading to this section has been originated in the latter application. The aim is to automatically classify and annotate shots in video sequences using medium level descriptions or genre. Genre extraction refers to a generic classification and it is an important step toward more specific semantic annotation of video data. According to their type

images and video shots can be cataloged into indoor, outdoor, vegetation, human faces, man-made objects, landscapes, buildings, etc. The focus here is on the classification of video sequences containing buildings and captured under natural outdoor lighting conditions. Existing approaches for classification of building images use a Bayesian framework to exploit image features by perceptual grouping, (Iqbal, 1999), binary Bayesian hierarchical classifiers, (Vailaya, 2001), or perform building semantic extraction using support vector machines (Wang, 2002), which are all described in the literature. The approach presented in this study exploits automatically extracted low-level features and specifically edge descriptors to achieve the classification process.

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The proposed technique has been inspired by a few empiric observations. In static image regions the likelihood of finding edge features that match the pattern of “buildings” is high because buildings are rigid and static objects. As a consequence, misclassification can be reduced by filtering out image areas changing or deforming in time. These regions can contain objects semantically different to buildings but with a highly similar edge distribution. However, in natural outdoor scenes varying lighting conditions severely influence the accurate detection of changing image areas. To deal with this problem illumination invariant detection of areas changing in time is required. Later in the text, a preprocessing step is described in which an improved filter is used to detect changing or deforming image regions. The results of this filtering process are combined with a fuzzy rule-based classifier aimed at automatic and accurate detection of a building. Selected experimental results are reported.

2. ILLUMINATION INVARIANT DETECTION OF CHANGING IMAGE AREAS

The approach proposed in this section requires a preprocessing phase to filter out image areas changing in time. The results of this initial filtering are fed into the classifier to improve the detection rate and reduce the probability of misclassification. Most existing algorithms for detection of changing regions in video sequences do not consider illumination changes inherent to exterior conditions (Fathy, 1995), (Skifstad, 1989), (Zeljko, 2003). For this reason the algorithms frequently fail when applied to natural outdoor scenes. The model presented in this section initially assumes that the background is static. However, this limitation has been released in the actual implementation by assuming that global motion parameters of background objects are known. Motion compensation is applied using conventional approaches. Under

this assumption the outcome of the preprocessing technique described below is the same if global motion parameters are used to compensate global changes of rigid background objects.

The preprocessing filter is a modification of the shading model method described in (Zeljko, 2003). I. It achieves invariance to extreme illumination changes at pixel level. If single frames in the video sequence are denoted by I , a window W of fixed size and position is superimposed on I and a sliding mask A_i , $i=1, \dots, n$ which performs scanning of W in each frame.

2.1. Skifstad and Jain's Method

Skifstad and Jain use the ratio of pixel intensities in A_i between two frames to estimate the pixel variance σ_i^2 as follows:

$$\sigma_i^2 = \frac{1}{\text{card}\{A_i\}} \sum_{m \in A_i} \left(\frac{B_m}{C_m} - \mu_{A_i} \right)^2, \quad i = 1..n \quad (1)$$

where B_m is a reference frame called *background* which does not contain changing regions, C_m is the current frame; B_m and C_m are pixel intensities within A_i , and μ_{A_i} is the mean of the pixel intensity ratio within A_i .

If $\sigma_i^2 \geq \varepsilon$ the center of A_i is marked as changing region, where ε is a suitable threshold.

Experiments have shown that for fast and large illumination changes this approach fails, i.e. some pixels are falsely assigned to changing regions, as explained in more details earlier in this section.

2.2 The Proposed Method

To overcome this shortcoming an improved and simplified version of the shading model method for changing region detection is applied. This version is invariant to extreme illumination changes at pixel level. The pixel variance σ_i^2 is defined as:

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