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Using local binary patterns for object detection in images

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Abstract

The article discusses a texture operator called Local Binary Patterns LBP and its applications in image processing and object detection We provide a description of the algorithm for computing LBP together with a rationale for using LBP as a feature for object detection and image recognition Based on the algorithm we show that LBP features have a low computational overhead compared to more complicated image features such as the commonly used SIFT or SURF features or neural network based approaches because they exploit the use of extremely fast bitwise and integer operations of the CPU We demonstrate that LBP is robust to changes in brightness contrast image rotation image scale We develop two enhancements for LBP that improve its resistance to camera noise and enhance the discriminative power of LBP when it is used as a feature for machine learning algorithms We present the results on a challenging real world object detection task

Keywords computer vision object detection local binary patterns

1. Introduction

Texture analysis is one of the basic steps of image analysis. Textures can contain structural lighting and view independent information about the scene. This information can be used as an input for segmentation, scene reconstruction or machine learning algorithms.

Traditionally, textures have been processed by transforming the 2D signal into the frequency domain using Fourier or more generally wavelet transforms and performing analysis in the frequency domain. There is a computational disadvantage of this approach because the transform can be costly and may need to be computed twice – into the frequency domain and back – depending on the application.

Local Binary Patterns (LBP) operator is a texture operator that directly manipulates the raster information of an image. The image does not need to be transformed into another domain which saves computational resources. The output of the LBP operator is an integer representing texture type at the given image pixel. This integer can be then directly used for further analysis in the subsequent higher level algorithms. The LBP operator also allows for an easy compensation for image rotation, scale, brightness and contrast transformations.

In the first part of the paper we provide a summary of existing LBP approaches and describe the algorithms for computing LBP. In the second part of the paper we propose two generalizations of LBP that allow for a more fine grained noise information content trade off.

2. Computing LBP

The LBP operator assigns an integer value to every pixel of the input image. The integer value is then interpreted as a texture class at the given pixel. The individual bits of the LBP integer are derived from local gradient information around every pixel as shown in

Figure 1. First, a circular neighbourhood is analysed and intensities of every point in this neighbourhood are compared to the intensity of the point in the circle's centre. Points with a lower intensity than the centre are assigned the value of 0; points with a higher intensity are assigned 1. The resulting string of zeroes and ones is interpreted as an integer that represents the texture class at the centre. More formally, the LBP value at the given image point (x, y) can be defined as

$$LBP_{p,r}(x, y) = \sum_{i=0}^{p-1} 2^i \text{thr}(I(x_i, y_i) - I(x, y))$$

where $LBP_{p,r}(x, y)$ is the LBP value at $[x, y]$, p the number of points in the circular neighbourhood, r radius of the neighbourhood, $I(a, b)$ image intensity at the coordinates a, b .

and $\text{thr}(v)$ a threshold function with threshold value of v . The $[x_i, y_i]$ coordinates represent points on the circle of the radius r .

The number of points p is usually set to the size of common computer registers or bits. Using these pattern sizes allows for a very efficient LBP manipulation.

Changing the radius r leads to a bigger or smaller neighbourhood. It is possible to reach scale invariance by computing LBP for multiple values of r . Usually r is increased by multiples of two every step, leading to a logarithmic number of LBP calculations per pixel in proportion to the image size.

By definition, the LBP operator is independent of brightness and contrast as neither adding nor multiplying the image intensity by a constant factor changes the sign of the difference between the LBP centre and the points in its circular neighbourhood.

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of uniform LBP which specifies rotation invariant patterns with at most two changes in the bit string. Other patterns are grouped together into an "other" category. This gives a total of $p + 2$ categories which significantly reduces the LBP space and allows for a simpler manipulation.

When applied to texture classification, uniform LBP provides state of the art results. However, for many object detection applications the values grouped to the "other" category results in classification problems as a lot of potentially useful information is lost.

3. Proposed extensions

3.1. Adaptive categorization

A careful analysis shows that the uniform LBP values can be generalized when described using two numbers: the number of bit changes t and the number of bits set to j . Setting a limit $t \leq 2$ yields a descriptor equivalent to uniform LBPs.

Because j and t are counts, they can each form a single scalar input to machine learning algorithms: an input neuron of a neural network, for instance.

The system was able to process one frame in _____ milliseconds on a dual core laptop processor

4. Conclusion

The extended LBP can be used for real time object detection as there s no need to pre process the input image the LBP computation uses only a fast integer and bitwise operations and is easily paralleli ed due to inherent LBP locality A further speed up can be achieved by implementing the method on graphics hardware

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