

Local Binary Pattern (LBP)

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Chapter 1

Introduction

1. Multiview Learning

Multi-view learning is an emerging direction in machine learning which considers learning with multiple views to improve the generalization performance. Multi-view learning is also known as data fusion or data integration from multiple feature sets.

2. Local Binary Pattern

Local binary pattern (LBP) is a nonparametric descriptor, which efficiently summarizes the local structures of images. In recent years, it has aroused increasing interest in many areas of image processing and computer vision and has shown its effectiveness in a number of applications, in particular for facial image analysis, including tasks as diverse as face detection, face recognition, facial expression analysis, and demographic classification. Derived from a general definition of texture in a local neighbourhood, LBP is defined as a grayscale invariant texture measure and is a useful tool to model texture images. LBP later has shown excellent performance in many comparative studies, in terms of both speed and discrimination performance. The original LBP operator labels the pixels of an image by thresholding the 3×3 neighbourhood of each pixel with the value of the central pixel and concatenating the results binomially to form a number. An LBP can also be considered as the concatenation of the binary gradient directions, and is called a *micropattern*. The histograms of these micropatterns contain information of the distribution of the edges, spots, and other local features in an image. LBP has been successfully used for face recognition. Different from statistic learning methods tuning a large number of parameters, the LBP method is very efficient due to its easy-to-compute feature extraction operation and simple matching strategy.

Chapter 2

Mathematical Formulation

1. Formulation

The original LBP operator labels the pixels of an image by thresholding the 3 x 3 neighbourhood of each pixel with the value of the central pixel and concatenating the results binomially to form a number. The thresholding function $f(.,.)$ for the basic LBP can be formally represented as

$$f(I(Z_0), I(Z_i)) = \begin{cases} 0, & \text{if } I(Z_i) - I(Z_0) \leq \text{threshold} \\ 1, & \text{if } I(Z_i) - I(Z_0) > \text{threshold} \end{cases}, i = 1, 2, \dots, 8 \quad (1)$$

Formally, given a pixel at (x_c, y_c) , the resulting LBP can be expressed in decimal form as follows:

$$\text{LBP}_{P, R}(x_c, y_c) = \sum_{P=0}^{P-1} s(i_P - i_c) 2^P$$

where i_c and i_P are, respectively, gray-level values of the central pixel and P surrounding pixels in the circle neighbourhood with a radius R , and function $s(x)$ is defined as

$$s(x) = \begin{cases} 1, & \text{if } x \geq 0 \\ 0, & \text{if } x < 0. \end{cases}$$

From the aforementioned definition, the basic LBP operator is invariant to monotonic gray-scale transformations, which preserve pixel intensity order in the local neighbourhoods. The histogram of LBP labels calculated over a region can be exploited as a texture descriptor.

Chapter 3

Algorithm

In this section, we give an overview of the LBP algorithm:

1. LBP algorithm

Algorithm:

Input : image in .jpg format

Output : LBP matrix of the image

1. Convert image into grid of pixels, represented by a matrix.
2. Select a centre pixel and examine its neighbouring pixels.
3. Set threshold value as centre pixel value.
4. Compare threshold value with each neighbouring pixels and assign binary number according to the following condition:

$$f(I(Z_0), I(Z_i)) = \begin{cases} 0, & \text{if } I(Z_i) - I(Z_0) \leq \text{threshold} \\ 1, & \text{if } I(Z_i) - I(Z_0) > \text{threshold} \end{cases}, i = 1, 2, \dots, 8 \quad (1)$$

where Z_0 represents central pixel and Z_i represents neighbouring pixels.

5. Read the binary values in clockwise or anti-clockwise order and convert the 8-bit binary number into decimal number.
 6. Replace the centre pixel value by the decimal number.
 7. Repeat the above steps for every pixel.
-

Chapter 4

Documentation of API

1. Package organization

```
from feature_extraction import lbp
```

2. Methods

def lbp(photo)

Returns LBP of an image

Parameters:

Photo: Input image

def assign_bit(picture, x, y, c)

To assign bits to the neighbouring pixels.

Parameters:

picture: input image

x: row co-ordinate

y: column co-ordinate

c: centre pixel

def local_bin_val(picture, x, y)

To calculate LBP value of a pixel.

Parameters:

picture: input image

x: row co-ordinate of centre pixel

y: column co-ordinate of centre pixel

Chapter 5

Example

1. Example 1

```
photo = cv2.imread("/content/fruits.jpg",1)
```

```
img_lbp=lbp(photo)
```

Output: array([[137, 249, 247, ..., 0, 45, 184],
[0, 112, 243, ..., 207, 94, 0],
[128, 224, 241, ..., 14, 57, 176],
...,
[14, 30, 1, ..., 19, 2, 0],
[2, 1, 160, ..., 177, 231, 192],
[129, 225, 224, ..., 225, 227, 128]], dtype=uint8)

2. Example 2

```
photo = cv2.imread("/content/dog.jpg",1)
```

```
img_lbp=lbp(photo)
```

Output: array([[62, 62, 58, ..., 62, 62, 56],
[255, 251, 241, ..., 255, 255, 248],
[243, 225, 255, ..., 255, 255, 248],
...,
[255, 131, 6, ..., 131, 231, 232],
[121, 255, 207, ..., 255, 199, 0],
[224, 227, 131, ..., 227, 131, 128]], dtype=uint8)

Chapter 6

Learning Outcome

- Capacity to integrate practical and theoretical knowledge to use local binary pattern's discriminative power and computational simplicity for texture recognition.
- Analysed and evaluated higher mathematical concepts with the ability to clearly implement and present the conclusions and the knowledge behind it.

Appendix A

References

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2. Song Ke-Chen, Yan Yun-Hui, Chen Wen-Gui, Zhang Xu. Research and perspective on local binary pattern. Acta Automatica Sinica, 2013