Theories and Applications of LBP: A Survey

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Abstract. LBP operator is one of the best performing local texture descriptors and it has been broadly used in texture classification, face recognition, face expression recognition and so on. Existing improvements and applications of LBP are studied and summarized in this paper. Traditional LBP is reviewed first. Then several typical improvements are presented according to their different applications. The conclusion and possible future work are also suggested.

Keywords: LBP, Texture classification, Face recognition, etc.

1 Introduction

Local Binary Pattern (LBP) features are originally proposed by Ojala et al. [1] for texture classification. It is a simple yet efficient local descriptor and proved to be an invariable feature for gray scale and rotation. Then LBP is successfully applied to face recognition [3]. It is also adapted to other applications, such as dynamic texture recognition [4], background modeling [23], facial expression analysis [4] and so on.

More and more attention is paid on LBP texture features [5-8]. Recently LBP also gains much attention on face recognition [15-22] for its robustness to illumination and pose variations. A great many improvements have been done on LBP, so a survey of the existing work on this topic is highly desirable for new comers.

Most improvements of LBP aim at enhancing discrimination for classification, whereas specific methods are different due to different applications. For example, texture analysis should be ideally invariant to viewpoint [9], which means rotation invariant features should be used to improve LBP in texture classification, while face recognition does not suffer from these requirements.

The methods covered in this paper are therefore broadly divided into three parts according to their practical applications: rotation invariant methods for texture classification, approaches for face recognition and other applications. We take a brief review of LBP at first, and then we present an overview of the existing work on LBP in the following sections, with the principles, merits and demerits of each approach outlined.

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2 Local Binary Pattern

Ojala et al. [1] introduce Local Binary Patterns to characterize the spatial structure of the local image texture. LBP code is computed by comparing a pixel with its neighbors:

$$LBP_{P,R}=\sum_{p=0}^{P-1}s(g_p-g_c)2^p,\qquad s(x)=\begin{cases}1, x\ge 0\\0, x<0\end{cases} \tag{1}$$

Where g_c represents to the center pixel and g_p(p=0,…,P-1) denotes to its neighbor on a circle of radius R, and P is the total number of the neighbors. The neighbors that do not fall in the center of pixels can be estimated by bilinear interpolation. The LBP encoding process is illustrated in Fig. 1.

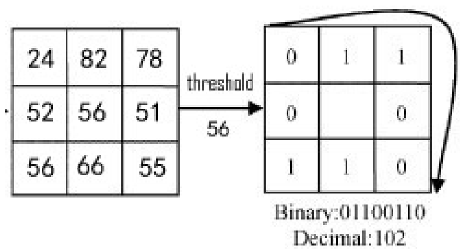

Fig. 1. Illustration of LBP (P=8, R=1)

Ojala et al. observe that certain local binary patterns provide the vast majority of all patterns [1]. Thus they define a uniformity measure U, which corresponds to the number of spatial transitions (bitwise 0/1 changes) in the pattern:

$$U(LBP_{P,R})=\left|s(g_{P-1}-g_c)-s(g_0-g_c)\right|+\sum_{p=1}^{P-1}\left|s(g_P-g_c)-s(g_{p-1}-g_c)\right| \tag{2}$$

The uniform patterns refer to those patterns which have U value of at most 2 and the remaining non-uniform patterns are all classified into to an additional class. Then a gray scale and rotation invariant texture descriptor is defined as:

$$LBP_{P,R}^{riu2}=\begin{cases}\sum_{p=0}^{P-1}s(g_p-g_c) & ifU(LBP_{P,R})\le 2\\ P+1 & otherwise\end{cases} \tag{3}$$

According to the definition, exactly P+2 patterns can occur in a circularly symmetric neighbor set of P pixels. After the LBP code of each pixel is defined, a histogram is built to represent the texture image.