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An Image Indexing and Retrieval Method Using Local Tetra Pattern for Content-Based Image Retrieval (CBIR)

Ms. Shraddha D. Jumade[#1], Prof. Sheetal S. Dhande[*2]

[#] *Sipna C.O.E.T., Amravati, Department Of Computer Science & Engg.,*
Sant Gadge Baba Amravati
University, Amravati (M.S.), India.

***Abstract*— Content-Based Image Retrieval gives the path to retrieve the needed information based on the image content. Here, we propose a novel image indexing and retrieval algorithm using Local Tetra Pattern (LT_rP) for Content-Based Image Retrieval (CBIR). The earlier versions of Content-Based Image Retrieval (CBIR) was based on Local Binary Pattern (LBP), Local Derivative Pattern (LDP) and Local Ternary Pattern (LTP). These methods encode the relationship between the referenced pixel and its surrounding neighbors by computing gray-level difference. These methods extract information based on the distribution of edges, which are coded using only two directions. The performance of these methods are little less and thus it can be improved by differentiating the edges in more than two directions. The proposed method encodes the relationship between the referenced pixel and its neighbors, based on the directions that are calculated using the first-order derivatives in vertical and horizontal directions. The performance is increased by differentiating the edges in four direction code, so called Local Tetra Pattern (LTrP) for Content- Based Image Retrieval (CBIR).**

Keywords: **Content-Based Image Retrieval (CBIR), Local Binary Pattern (LBP), Local Tetra Pattern (LTrP).**

I. INTRODUCTION

The explosive growth of digital libraries due to web cameras, digital cameras, and mobile phones equipped with such devices is making the database management by human annotation an extremely tedious and clumsy task. Thus there exists a dire need for developing an efficient expert technique that can automatically search the desired image from the huge database. Content-Based Image Retrieval (CBIR) is one of the commonly adopted solutions for such applications. The feature extraction in Content-Based Image Retrieval (CBIR) is a prominent step whose effectiveness depends upon the method adopted for extracting features from given images [12]. The Content-Based Image Retrieval (CBIR) utilizes visual contents of an image such as color, texture, shape, faces, spatial layout, etc., to represent and index the image database. These features can be further classified as General Features such as color, texture, and shape, and Domain Specific features such as human faces, fingerprints, etc. The difficulty to find a single best representation of an image for all perceptual subjectivity is due to the fact that the user may take photographs in different conditions such as view angle, illumination changes, etc. The search for relevant information in the large space of image databases has become more challenging. Image processing is the science of enhancing an image in order to increase the image quality and to extract useful information from the image. Image can be RGB color, grayscale or binary.

Content-Based Image Retrieval (CBIR) is the retrieval of image based on visual features such as color, texture and shape. Shape is a visual feature that describes the contours of objects in an image, which are usually extracted from segmenting the image into meaningful regions or objects. In general, the shape representations can be divided into two categories, boundary-based and region-based. The former uses only the outer boundary of the shape while the latter uses the entire shape region. One of the important features that make possible the recognition of images by humans is color. Color is a property that depends on the reflection of light to the eye and the processing of that information by the brain [10]. Texture refers to visual patterns with properties of homogeneity that do not result from the presence of only a single color such as clouds and water [12]. Texture features typically consist of contrast, uniformity, coarseness, and density. In Content -Based Image Retrieval (CBIR), each image that is stored in the databases has its features extracted and compared to the features of the query image.

It involves two steps:

1. Feature Extraction: It extracts image features to a distinguishable extent.
2. Matching**:** It involves matching these features to yield a result that is visually similar [7].

II. RELATED WORK

The Local Binary Patterns (LBP) feature has emerged as a silver lining in the field of texture classification and retrieval. T. Ojala et al. proposed Local Binary Patterns (LBP) which are converted to a rotational invariant version for texture classification [11][8]. They proposed the Local Binary Patterns (LBP) operator which describes the surroundings of a pixel by generating a bit-code from the binary derivatives of a pixel as a complementary measure for local image contrast. The Local Binary Patterns (LBP) operator takes the eight neighboring pixels using the center gray value as a threshold. Local Binary Patterns (LBP) descriptor was used for capturing texture information of face appearance. A novel and efficient facial image representation based on Local Binary Pattern (LBP) texture features is presented , where face image is divided into several regions from which the Local Binary Pattern (LBP) feature distributions are extracted and concatenated into an enhanced feature vector to be used as a face descriptor [9][6].

The Local Ternary Patterns (LTP) has been introduced for face recognition under different lighting conditions. Tan and Trigg's [3] extended the Local Binary Patterns (LBP) to a three-valued code called the Local Ternary Patterns (LTP). A rich descriptor for local texture called as Local Ternary Patterns [4].. Local Ternary Patterns (LTP) includes a three valued coding that includes a threshold around zero for improved resistance to noise.

B. Zhang *et al.* proposed Local Derivative Patterns (LDP) for face recognition [4], where they considered the Local Binary Patterns (LBP) as non-directional first-order local patterns collected from the first-order derivatives and extended the same approach for n^{th} order Local Derivative Patterns (LDP). In this framework [5] to encode directional pattern features based on local derivative variations.

The Local Binary Patterns (LBP), the Local Derivative Patterns (LDP) and the Local Ternary Patterns (LTP) extract the information based on the distribution of edges, which are coded using only two directions (positive direction or negative direction). It is possible that the performance of these methods can be improved by differentiating the edges in more than two directions that is nothing but four direction code, referred to as Local Tetra Patterns (LTrP) for Content-Based Image Retrieval (CBIR)[4].

III. LOCAL PATTERNS

- **Local Binary Pattern (LBP) :**

The Local Binary Pattern (LBP) was introduced for texture classification[1]. It is defined as a grayscale invariant texture measure and is useful tool to model texture images. Given a center pixel in the image, the LBP value is computed by comparing its gray value with its neighbors, as shown below :

$$\mathrm{LBP}_{P,R} = \sum_{p=1}^{P} 2^{(p-1)} \times f_1(g_p - g_c)$$

$$f_1(x) = \begin{cases} 1, & x \geq 0 \\ 0, & \text{else} \end{cases}$$

Where g_c is the gray value of the center pixel ,g_p is the gray value of its neighbors, P is the number of neighbors, and R is the radius of the neighborhood.

- **Local Ternary Pattern (LTP) :**

Tan and Triggs [3] extended the LBP to a three-valued code called the LTP, in which gray values in the zone of width $\pm t$ around are quantized to zero, those above (g_c+t) quantized to +1, and those below(g_c-t) are quantized to -1, i.e., indicator $f_1(x)$ is replaced with three-valued function and the binary LBP code is replaced by a ternary LTP code, as shown below :

$$\hat{f}_1(x, g_c, t) = \begin{cases} +1, & x \geq g_c + t \\ 0, & |x - g_c| < t \\ -1, & x \leq g_c - t \end{cases} \Bigg|_{x=g_p}.$$

- **Local Derivative Pattern (LDP) :**

Zhang et al. proposed the LDP for face recognition [5]. They considered the LBP as the non-directional first-order local pattern operator and extended it to higher orders (n^{th}order) called the LDP. The LDP contains more detailed discriminative features as compared with the LBP.To calculate the n^{th}order LDP [11], the $(n-1)^{th}$ order derivatives are calculated along 0^0, 45^0 , 90^0, and 135^0 directions denoted as $I_\alpha^{(n-1)}(g_c)|_{\alpha=0^\circ,45^\circ,90^\circ,135^\circ}$. Finally, n^{th} order LDP is calculated as:

$$\mathrm{LDP}_\alpha^n(g_c) = \sum_{p=1}^{P} 2^{(p-1)} \times f_2\left(I_\alpha^{(n-1)}(g_c), I_\alpha^{(n-1)}(g_p)\right)\Bigg|_{P=8}$$

$$f_2(x, y) = \begin{cases} 1, & \text{if } x.y \leq 0 \\ 0, & \text{else.} \end{cases}$$

As reviewed above the LBP, LDP and LTP extract the information based on the distribution of edges, which are coded using only two directions (positive direction or negative direction). So four direction code referred as Local Tetra Pattern (LTrP) for Content- Based Image Retrieval (CBIR) for image indexing and retrieval is proposed, due to which improvement in the result will surly occurs .

IV. PROPOSED METHOD

The idea of local patterns (the LBP, the LDP, and the LTP) has been adopted to define Local Tetra Patterns (LTrP) [1]. The Local Tetra Pattern (LTrP) describes the spatial structure of the local texture using the direction of the center gray pixel. Let gc denote the center pixel in image I, gh and gv denote the horizontal and vertical neighbors of gc, respectively. The standard Local Binary Pattern (LBP) and Local Ternary Pattern (LTRP) encode the relationship between the referenced pixel and its surrounding neighbors by computing grey-level difference.

A novel image indexing and retrieval algorithm using Local Tetra Patterns (LTrP) for Content-Based Image Retrieval (CBIR) is as follows [4] :

Input : Query Image.

Output : Retrieval Result.

1. Load the image.
2. Calculate the direction of pixels.
3. Divide patterns into four parts based on the direction of center pixel.
4. Calculate first order derivatives of center pixel in horizontal and vertical axis using,

$$I^1_{0^\circ}(g_c) = I(g_h) - I(g_c)$$
$$I^1_{90^\circ}(g_c) = I(g_v) - I(g_c)$$

Where, g_c is center pixel of image.
g_h is pixel in horizontal direction of image.
g_v is pixel in vertical direction of image.

5. Calculate magnitude of pixel using,

$$M_{I^1(g_p)} = \sqrt{(I^1_{0^\circ}(g_p))^2 + (I^1_{90^\circ}(g_p))^2}$$

Where , g_p pixel of image.

6. Construct binary pattern.
7.Compare the query image with the images in database.
8.Retrive the images based on best matches.

Now Details About Stages Of Implementation Of Proposed Work :

1) Calculation Of Direction Of Pixel And First Order Derivatives Of Center Pixel :-

As mentioned in the proposed algorithm first load the input or query image. That is nothing but digital image to which we want to find matched images in the database. After loading the image convert it into representation of pixel values. Using these pixel values calculate centroid or centre of query image. For Direction Pattern calculate neighboring pixel values also. After that calculate first order derivatives of center pixel in horizontal and vertical axis using,

$$I^1_{0^\circ}(g_c) = I(g_h) - I(g_c)$$
$$I^1_{90^\circ}(g_c) = I(g_v) - I(g_c)$$

Where, g_c is center pixel of image.
g_h is pixel in horizontal direction of image.
g_v is pixel in vertical direction of image.

2) Construction Of Magnitude And Binary Pattern :-

After calculation of first order derivatives of center pixel in horizontal and vertical axis next step is calculation of Magnitude Pattern using values obtained by first order derivatives of pixel. Calculate Magnitude of pixel using,

$$M_{I^1(g_p)} = \sqrt{(I^1_{0^\circ}(g_p))^2 + (I^1_{90^\circ}(g_p))^2}$$

Where, g_p is pixel of image, here g_p is nothing but g_c center pixel of image.

After calculation of magnitude next step is finding Binary Pattern. As proposed work is done using Local Tetra Pattern then by using four regions calculate binary pattern of query image.

Following Figure 1 shows the actual implimentation of above stage 1 and stage 2 of proposed work.

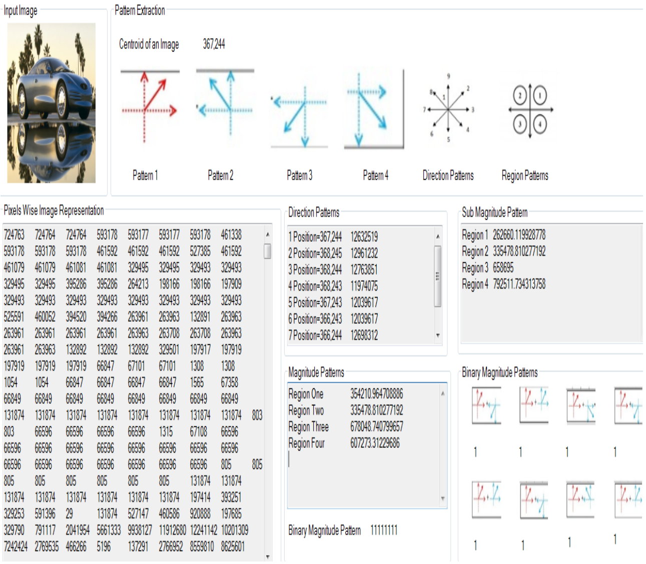

Figure1: Calculation of magnitude and binary pattern of input or query image.

3) Retrieving the Result :-

As from the loading the query image to finding it's binary pattern this whole work is also done with each image in the database.Comparison is done between query and each image in the database which matched with that of query image. After comparison of binary patterns of query image and matched images from database, images with having difference is retrieved. Top matched images are arranged i.e. images are arranged in increasing difference. If we change the parameters of query image and then also retrieval result is same as that of result of original query image. Because after change in query image then also it finds it's best matches as that of original query image which is our main intention of this work.

Figure 2 shows the implimentation of stage 3 of proposed work.

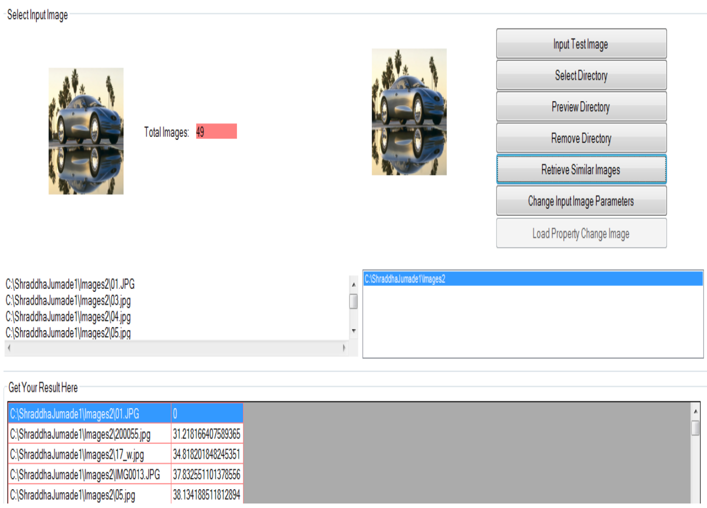

Figure 2: Retrieving the matched images from database with input or query image.

CONCLUSION

Content-Based Image Retrieval (CBIR) , where retrieval is based on the matching of feature of query image with that of image database through some image-image similarity evaluation. Here a novel approach referred as Local Tetra Pattern (LTrP) is suggested , which encodes the relationship between the center pixel and its neighborhood pixels based on directions that are calculated using $(n-1)^{th}$ order horizontal and vertical derivatives for n^{th} order Local Tetra Pattern (LTrP) for efficient Content-Based Image Retrieval (CBIR). It has been observed that the second-order Local Tetra Pattern (LTrP) provides better performance as compared with higher order Local Tetra Patterns (LTrP). Because higher order Local Tetra Patterns (LTrP) are more sensitive to noise. Due to the effectiveness of the proposed method, it can be also suitable for other pattern recognition applications such as face recognition, fingerprint recognition, etc.

FUTURE SCOPE

A novel approach referred as Local Tetra Pattern (LTrP) for Content- Based Image Retrieval (CBIR) is presented in above work. The Local Tetra Pattern (LTrP) encodes the images based on the direction of pixels that are calculated by horizontal and vertical derivatives. As this method uses calculation of the magnitude pattern and binary pattern for pixel in the image, it improves the image retrieval rate and image retrieval time. In this proposed system, only horizontal and vertical pixels have been used for derivative calculation. Results can be further improved by considering the diagonal pixels for derivative calculations in addition to horizontal and vertical directions. Due to the effectiveness of the proposed method, it can be also suitable for other pattern recognition applications such as face recognition, fingerprint recognition, etc.

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