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Comparison of Local Binary Pattern Variants for Ultrasound Kidney Image Retrieval

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Abstract - Local Binary Pattern (LBP) is a simple yet very efficient texture operator which labels the pixels of an image by threshold the neighbourhood of each pixel and considers the result as a binary number. Due to its discriminative power and computational simplicity, LBP texture operator has become a popular approach in various applications. It can be seen as a unifying approach to the traditionally divergent statistical and structural models of texture analysis. In this paper, the concept of LBP is applied to Ultrasound Kidney Image Retrieval system. For extracting the texture features from ultrasound kidney images the LBP, rotational invariant LBP and centre symmetric LBP operator is used. The performance of ultrasound kidney image retrieval system with LBP operator, Rotational Invariant LBP operator and centre symmetric LBP is compared. The efficiency of the system is measured by Recall and Precision parameters. The experimental results show that the centre symmetric LBP operator gives the better performance for retrieving ultrasound kidney images.

Keywords— CBIR, Ultrasound Kidney Image, Local Binary Pattern, Rotational Invariant Local Binary Pattern, center symmetric LBP ,Recall, Precision.

I. INTRODUCTION

With the immense advancements in information technology, there is a great growth of image databases, which requires effective and efficient system that allows user to search through such a large pool. Traditionally, the conventional database-management systems such as relational databases or object-oriented databases are used for this purpose. The system of these kinds are usually called Text-based, in which the images are described with keywords. As the database size grows larger, retrieval of a particular image using these methods become tedious and inadequate. To solve these problems, content-based image retrieval (CBIR) has emerged as a promising approach. In CBIR, images are indexed by their own visual contents. A comprehensive and extensive literature survey on CBIR can be found in [1]–[3]. The important application of CBIR is in medical domain aiding the diagnosis.

This Paper applies the concept of CBIR in ultrasound Kidney images. For any class of biomedical images, the requirement is to develop suitable feature representation for the visual contents and similarity algorithms that capture the "content" in the image. The visual characteristics of images are represented by a features like color, texture and shape. But for grey level medical images, texture and shape features are normally preferred for diagnosis purpose. Texture feature plays an important role in medical image analysis. There are many texture extraction methods are available. The previous work of ultrasound kidney images Retrieval system uses GLCM[4-6] technique for texture feature representation. But the major problem in the GLCM technique is that it requires more computational time to form the GLCM matrix and then more features are to be derived for representing texture. So, there is a need of the feature extraction technique which extracts the texture feature in a less computational complexity and has a good discriminative power.

Local Binary Pattern (LBP) is a simple but efficient texture operator which labels the pixels of an image by threshold the neighborhood of each pixel and resulting a binary number. Due to its discriminative power and computational simplicity[7], LBP texture operator has become a popular approach in various applications. This paper uses the LBP operator for texture description.

The structure of the paper is organized as follows. Section II describes the concept of LBP applied over ultrasound kidney images. Section III illustrates Rotational invariance applied in LBP for ultrasound kidney images. Section IV explains center symmetric LBP employed in ultrasound kidney images. Section V gives the similarity matching. Section VI reports the experimental Results. Conclusion is given in section VII.

II. ULTRASOUND KIDNEY IMAGE RETRIEVAL USING LBP

The basic idea for developing the LBP operator was that two-dimensional surface textures can be described by two complementary measures. They are local spatial patterns and grey scale contrast. The original LBP operator [7] gives labels for the image pixels by threshold the 3 x 3 neighbourhood of each pixel with the center value and summing the threshold values weighted by powers of two which results a binary number. The histogram of these $2^8 = 256$ different labels can then be used as a texture descriptor.

The LBP value for the center pixel (a,b) of the image f(a,b) is calculated using the equation 1.

$$LBP(a,b) = \sum_{i=0}^{7} U(f(a,b) - f(a_i, b_i))2^i \qquad (1)$$

Where U(x) is the thresholding function which is defined in the equation 2.

$$U(x) = \begin{cases} 1 \ if \ x \geq 0 \\ 0 \ if \ x < 0 \end{cases} \qquad (2)$$

The Computation of LBP value for the 3x3 window for the ultrasound kidney image is explained in fig 1.

Example

6	5	2
7	6	1
9	8	7

Binary Pattern

1	0	0
1		0
1	1	1

Weights

1	0	0
128		0
64	32	16

LBP Value

	241	

LBP = 1+16+32+64+128=241

Fig 1: Computation of LBP value

The histogram of LBP values for an image I is stored as its feature. LBP is an operator for image description that is based on the signs of differences of neighbouring pixels. It is fast to compute and invariant to monotonic grey-scale changes of the image.

III. ULTRASOUND KIDNEY IMAGE RETRIEVAL USING ROTATIONAL INVARIANT LBP

Even though LBP is a texture feature but it relies on intensity information. Intensity information is very sensitive with the illumination changes. The feature which is robust to illumination changes are very much needed for medical image analysis. The rotational invariant feature[8] is independent of angle of the input image. Then the rotational invariant LBP is applied for image analysis.

The rotational invariant LBP for an image f(a,b) is calculated as follows. The LBP value for the pixel (a,b) is calculated using the equation 1. Consider that binary value is $A_7A_6A_5A_4A_3A_2A_1A_0$. This binary value is rotated in a left direction one bit at a time and getting the new value. This procedure is continued for all the eight bits and getting eight values. The minimum value among this eight values is assigned as the rotational invariant LBP (RLBP) for the pixel (a,b).The rotational invariant LBP calculation of the pixel (a,b) for an image f(a,b) is defined equation 3.

$$RLBP(a,b) = Min(Rot(LBP(a,b),8)) \qquad (3)$$

In Equation 3, the function Rot(x), is used to shifting the value x in anticlockwise direction one bit at a time. The value 8 represented the 8 possible rotation. The histogram of RLBP values for an image I is stored as its feature.

IV. ULTRASOUND KIDNEY IMAGE RETRIEVAL USING CENTER-SYMMETRIC LBP

The Rotational invariant LBP involves rotation after the LBP computation of center pixel. The rotation is done 8 times. The minimum value among the 8 rotations can be taken as the LBP value for center pixel. To reduce the computational complexity and reduce the feature representation Center-Symmetric Local Binary Pattern(CS-LBP) concept is introduced. Center-Symmetric Local Binary Patterns (CS-LBP) [9] aims for smaller number of LBP labels to produce shorter histograms that are better suited to be used in region descriptors. Also, CSLBP was designed to have higher stability in flat image regions. In CS-LBP, pixel values are not compared to the center pixel but to the opposing pixel symmetrically with respect to the center pixel.

The CS-LBP calculation of the center pixel(a,b) of the image f(a,b) is given in equation 4. The value P in the equation denotes the number of neighboring pixels which is 8 for our experiment.

$$CS-LBP(a,b)=\sum_{p=0}^{(P/2)-1}U(f(a_p,b_p)-f(a_{p+P/2},b_{p+P/2}))2^p \quad (4)$$

The fig 2 illustrates the concept of CS-LBP calculation.

Method	Recall	Precision	Length of Histogram

Example

6	5	9
7	6	1
2	8	7

CS-LBP Value

	4	

CS-LBP = $U(6-7)2^0+U(5-8)2^1+U(9-2)2^2+U(1-7)2^3$
= 0+0+4+0=4

Fig 2: Computation of CS-LBP value

To increase the operator's robustness in flat areas, the differences are thresholded at a typically non-zero threshold T . It should be noticed that the CS-LBP is closely related to gradient operator, because like some gradient operators it considers gray level differences between pairs of opposite pixels in a neighborhood. The histogram of CS-LBP values for an image I is stored as its feature.

V.SIMILARITY MATCHING

Medical CBIR calculates the visual similarities between a query image and images in a database instead of exact matching for diagnosis. Accordingly, the retrieval result is not a single image but a list of images ranked by their similarities with the query image. Many similarity measures have been developed for image retrieval based on empirical estimates of the distribution of features in recent years. Different similarity distance measures will affect the retrieval performances of an image retrieval system significantly. The Chi square distance[10] measure is best for histogram based matching.

To calculate the Chi-square distance between the query image and the images of the database the formula given in equation (5) is used.

$$D(x,y)=Sum((x_i-y_i)^2/(x_i+y_i))/2 \quad (5)$$

In Equation 5, x and y are query image histogram and database image histogram respectively. The value of i in the equation (5) is varied from 0 to 255.

VI. EXPERIMENTAL RESULTS

Database consists of 100 ultrasound kidney images of different categories [like Normal kidneys, cortical cysts (CC), medical renal diseases (MRD)] are taken for performance analysis. The performance of ultrasound kidney image retrieval system using LBP, Rotational invariant LBP and center symmetric LBP is analyzed. The efficiency of the CBIR system is evaluated by two familiar measures precision and recall [11-13] which is defined in equation 6 and equation 7.

$$Precision=\frac{No\_of\_Relevant\_images\_Retrieved}{Total\_No\_of\_images\_Retrieved} \quad (6)$$

$$Recall=\frac{No\_of\_Relevant\_images\_Retrived}{Total\_no\_of\_images\_in\_Database} \quad (7)$$

The efficiency of the system is evaluated on different category of images (Normal, CC, MRD). The number of similar images retrieved depends on the value of the threshold set on the chi-square measure. The efficiency of the system is checked over the different threshold value. The behaviour of ultrasound kidney image retrieval system based on LBP, Rotational invariant LBP and center symmetric LBP are tested for fixing various threshold values. The highest value which has the good discriminating power is taken as threshold(T).In this 'T' value the center symmetric LBP (CS-LBP) outperforms than LBP method and Rotational Invariant LBP methods. The average recall and precision values of three systems are listed in Table1.

Table I

AVERAGE RECALL AND PRECISION VALUES OF CSLBP, RLBP AND LBP FOR ULTRASOUND KIDNEY IMAGE RETRIEVAL SYSTEM

CS-LBP	**0.82**	**0.94**	**16**
RLBP	**0.77**	**0.94**	**256**
LBP	**0.68**	**0.9**	**256**

The Database consists of different category of ultra sound kidney images like Normal, CC, MRD are experimented with three techniques. The fig. 3 and 4 shows the precision and recall analysis of ultrasound kidney images. From the graph, it is understood that CS-LBP based ultrasound kidney image retrieval system has better recall and precision values in average than RLBP and LBP based ultrasound kidney image retrieval system.

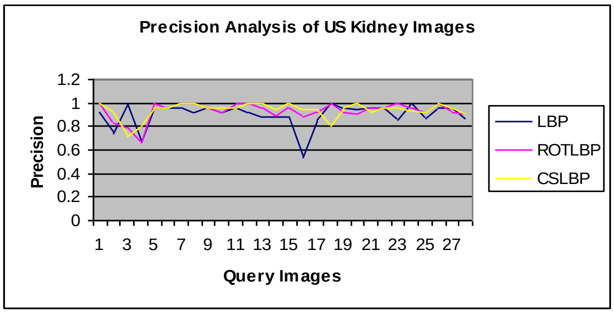

Fig 3. Precision Analysis for Ultrasound kidney Images

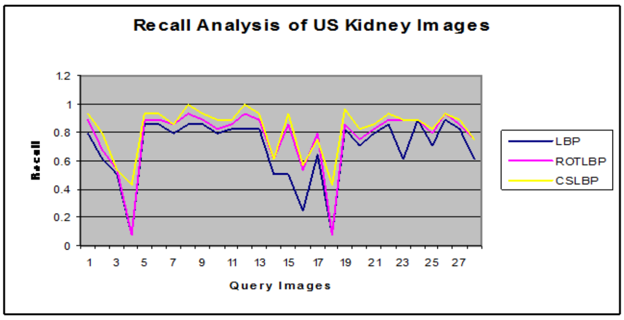

Fig 4. Recall Analysis for Ultrasound kidney Images

VII.CONCLUSION

This paper has compared the efficiency of LBP, Rotational invariant LBP(RLBP) and center symmetric LBP(CS-LBP) for ultrasound kidney image retrieval. The experimental analysis provided the proof about the better method among the two. The Center Symmetric LBP (CS-LBP) retrieved more number of similar images effectively. The Center Symmetric LBP (CS-LBP) has the highest average recall value (82%) and highest precision value (94%). So this work, suggested that the Center Symmetric LBP (CS-LBP) is the suitable technique of retrieving ultrasound kidney images than the other LBP variants method.

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