RTL: Reduced Texture spectrum with Lag value Based Image Retrieval for Medical Images

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Abstract

Medical images have become the recent key investigation tools for medical diagnosis and treatment planning. Due to the advent of digital imaging the need of data storage and retrieval of medical images increased rapidly. Some difficulties in retrieving the medical images are: medical images have only intensity images that carry less information, more noise and records of medical images are large and complex to analyze. To address these problems the present work proposes a novel scheme based on Texture Unit. The proposed scheme reduces texture unit values from 0 to 6561 to 0 to 255 based on Lag values. The Similarity measures are extracted on both schemes and a good comparison is made. The experimental results on MRI images indicate reliability, feasibility and efficacy of the proposed method.

Keywords: *CBIR, Texture, Medical Image Retrieval*

1. Introduction

The increasing reliance of modern medicine on diagnostic techniques such as radiology, Computerized Tomography (CT) has resulted in an explosion in the number and importance of medical images [1, 2, 3, 4]. The ocean of information available would be useless without the ability to manipulate, classify, archive and access them quickly and selectively. One of the main problems was the difficulty of locating the desired image in a large and varied collection, while it is perfectly feasible to identify the desired image from a small collection simply by browsing. Medical image retrieval systems address this problem [5, 6, 8].

The prime requirement for medical imaging systems is to be able to display images relating to a named patient. The text indexing is often limited, tedious and subjective for describing image content. So there is an increasing interest in the use of CBIR techniques to aid diagnosis by identifying similar past cases. Queries to CBIR system are most often expressed as visual examples of the type of the image or image attribute being sought. For example user may submit a sketch, click on the texture pallet, or select a particular shape of interest. This system then identifies those stored images with a high degree of similarity to the requested feature.

1.1 Medical CBIR

Medical Image acquisition devices such as Computed Tomography (CT) scanners, Magnetic Resonance Imagers (MRI), Ultrasound probes (Us) provide images with various properties in terms of resolution, contrast and signal to noise ratio. They also produce images with different information on the human body anatomy and physiology [5, 6].

Development of Medical image indexing and retrieval tools is difficult because of certain factors such as

1. In most cases, medical images are only intensity images carrying less information than colour images. In some rare cases however, vectorial images may be produced (e.g. tensor MRI). More frequently, multimodality images of a same body may be acquired (e.g. MRI and ultrasound images of the same area). However, multiple images are usually not aligned in space and require an additional registration procedure.
2. Medical images are usually of low resolution and high noise images. They are difficult to analyze for extracting features automatically. Medical images acquired with different devices, even using the same modality, may have significantly varying properties. Some authors proposed image correction and normalization algorithms to improve image comparison.

3. Ideally, medical images should be indeed on medical criteria that are extremely variable depending on the kind of image acquisition considered (imaged body area, clinical context, etc). Moreover, automatic diagnosis in medical images is mostly impossible today except in rare specific cases. Medical images interpretation is often difficult even for trained radiologists.

On the other hand today, large fraction medical acquisition devices produce 3D data that provide additional information which is not available in 2D images. The use of 3D, and sometimes multi-sequence, data may enable powerful feature detection in some cases.

As [2] notice, the medical image retrieval must often be processed according to pathology bearing regions which area precisely delimited on the images and could not be automatically detected in the general case. Moreover, low level features like colour, texture or shape are not sufficient to describe medical images. As a consequence, medical CBIRs require a high level of content understanding and interpretation of images, which implies their automatic segmentation [1]. Finally, a high level of query completion and accuracy is required by such systems to make them reliable from a clinical point of view [8].

To overcome the difficulty caused due to medical images, the present work proposes a Novel scheme based on texture unit. The proposed scheme reduces texture unit values from 0 to 6561 to 0 to 255 based on lag values. The similarity measures IHBM [30] are applied on the proposed methods and on the existing method for comparing the query image with database images for effective retrieval of relevant images.

The remainder of the paper is organized as follows. In Section 2, describes on Feature extraction and representations , Section 3 describes methodology of existing and proposed RTL, section 4 describes experimental Results, and finally describes the Conclusions in section 5.

2. Feature Extraction and Representation

2.1 The Texture

Texture is one of the crucial primitives in human vision and texture features have been used to identify content of images. Texture refers to the visual patterns that have properties of homogeneity that do not result from the presence of only a single color or intensity. Texture contains important information about the structural arrangement of surfaces and their relationship to the surrounding environment.

One crucial distinction between color and texture features is that color is a point, or pixel, property, whereas texture is a local-neighborhood property. As a result, it does not make any sense to discuss the texture content at pixel level without considering the neighborhood. Texture has long been an important topic in image processing [7,12,16,17,18,19,23,24,25]. Methods of texture analysis are usually divided into two major categories [14,24]. The first is the structural approach, where texture is considered as a repetition of some primitives, with a specific rule of placement. The traditional Fourier spectrum analysis and wavelet based analysis [28] are often used to determine the primitives and placement rule. Several authors have applied these methods to texture classification and texture characterization with a certain degree of success [21]. The second major approach in texture analysis is statistical method. Its aim is to characterize the stochastic properties of the spatial distribution of gray levels in an image. The gray tone co-occurrence matrix is frequently used for such characteristics. A set of textural features derived from the co-occurrence matrix is widely used to extract textural information from digital images [18,20]. Study of patterns on textures is recognized as an important step in characterization and classification of textures. Textures are classified recently by various pattern methods, viz., preprocessed images [12], long linear patterns [11,27], and edge direction movements [22], Avoiding Complex Patterns [10], marble texture description [15]. Textures are also described and classified by using various wavelet transforms: one based on primitive patterns [13], and another based on statistical parameters [29].

3. Methodology

3.1Texture Unit and Texture Spectrum

The texture image can be decomposed into a set of essential small units, called *Texture Units (TU)*. As the texture unit represents the local texture aspect, the statistics of Texture Units in an image should reveal its texture information. The occurrence distribution of Texture Units is called as *Texture Spectrum (TS)*, with the ‘abscissa’ indicating the type of Texture Unit and the ‘ordinate’ representing its occurrence frequency.

This section gives a brief review of the Texture Unit (TU) and proposes different methods of calculating texture unit, from which texture spectrum will be constructed. The TU is introduced and described in detail by D.C. He and Li Wang [7,9,26]. The basic concept is that a texture image can be considered as a set of essential small units termed as texture units, which characterize the local texture information for a given pixel and its neighborhood.

In a square-raster digital image, each pixel is surrounded by eight neighboring pixels. The local texture information for a pixel can be extracted from a neighborhood of 3×3 pixels, which represents the smallest complete unit (in the sense of having eight directions surrounding the pixel). A neighborhood of 3×3 pixels is denoted by a set containing nine elements: $V = \{V_0, V_1 \ldots V_8\}$, here V_0 represents the intensity value of the central pixel and V_i $\{i = 1, 2 \ldots 8\}$, is the intensity value of the neighboring pixel i. Based on this the corresponding TU is defined by a set containing eight elements. TU = $\{E_1, E_2 \ldots E_8\}$, where E

$_i$ (i=1, 2….8) is determined by the formula [7,9,26] given in equation 1 and the element E $_i$ occupies the same position as the pixel i.

$$E_i = \left\{ \begin{array}{lll} 0 & if & V_i < V_0 \\ 1 & if & V_i = V_0 \;\; for: i = 1,2,...8 \\ 2 & if & V_i > V_0 \end{array} \right\} ....(1)$$

As each element of TU has one of the three possible values, the combination of all the eight elements results in $3^8 = 6561$ possible texture units in total. There is no unique way to label and order the 6561 texture units. The 6561 texture units are labeled by [7,9,26] using the following equation 2:

$$N_{TU} = \sum_{i=1}^{8} E_i \times 3^{i-1}, N_{TU} \in \{0,1,......(3^8 - 1)\}......(2)$$

Here N_{TU} represents the texture unit number and E_i is the ith element of texture unit set TU = {E_1, E_2… E_8}.

The ordering of elements is shown in Figure 1. The size of the window depends on the nature of the texture image [7,26]. And the process of formation of a Texture Unit is given in Figure 2.

E_1	E_2	E_3
E_8		E_4
E_7	E_6	E_5

Figure 1. Ordering of eight elements, for Texture Unit

39	45	50		0	1	2
39	45	190	→	0		2
45	39	190		1	0	2

Figure 2. Example of Transforming a Neighborhood to a Texture Unit

3.2 Proposed methods for Texture Unit and Texture Spectrum

The classification, and recognition of textures becomes complex by the above method due to large number of TU that ranges from 0 to 6561. The proposed scheme reduces the above complexity by reducing overall TU from 0 to 255. For this the proposed paper outlines two methods. The method 1 is named as Reduced Texture Spectrum (RTS) and the method 2 is named as Reduced Texture spectrum with Lag value (RTL) and they are explained below.

3.2.1 Reduced Texture Spectrum (RTS):

In RTS, the texture unit is defined by the following equation 3.

$$E_i = \begin{array}{ll} 0 & if\ V_i < V_0 \\ 1 & if\ V_i \geq V_0 \end{array} \quad for\ i = 1,2,...8 \quad .....(3)$$

and the element E $_i$ occupies the same position as the pixel i.

Since each element of TU in the present method has one of the two possible values, the combination of all the eight elements results in $2^8 = 256$ possible texture units in total. There is no unique way to label and order the 256 texture units. The 256 texture units are labeled by using the following equation 4:

$$N_{TU} = \sum_{i=1}^{8} E_i \times 2^{i-1}, N_{TU} \in \{0,1,......(2^8 - 1)\}............(4)$$

Here N_{TU} represents the texture unit number and E_i is the i^{th} element of texture unit set TU = $\{E_1, E_2... E_8\}$. An example of proposed TU is given below in Figure 3.

39	45	50
39	45	190
45	39	190

→

0	1	1
0		1
1	0	1

Figure 3. Transformation model of a neighborhood to a Texture Unit by the proposed RTS

From Figure 3. ,Vo is 45 ,according to Equation 3, 45 is same as 45 and 50 is greater than 45, TU is taken as 1, whereas 190 is also greater than 45 and TU is also 1, so that 50 and 190 are treated as same, this is the motivation for the RTL and shown by Figure 4.

3.2.2 Reduced Texture spectrum with Lag value (RTL):

Based on the assumption that the texture is a local neighborhood property, the proposed method has given only two possible values for a Texture Unit i.e., {0, 1} based on Lag values, given in equation 5. The Lag value makes the certain range of values on either side to fall into one group. This reflects the close neighborhood property.

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$$E_i = \begin{matrix} 0 & \text{if } V_i < V_0 + L \\ 1 & \text{if } V_i \geq V_0 + L \end{matrix} \quad \text{for } i = 1,2,...8 \quad .....(5)$$

and the element E_i occupies the same position as the pixel i, L is the Lag value.

If L=0, then RTL and RTS becomes same.

The transformation process of a TU based on RTL with a Lag value 10 is shown in Figure 4.

39	45	50
39	45	190
45	39	190

→

0	0	0
0		1
0	0	1

Figure 4.Transformation model of a neighborhood to a Texture Unit by the proposed RTL

The similarity measures IHBM [30] are applied on the proposed methods and on the existing method for comparing the query image with database images.The principle of the similarity measure is the computation of the distance between the extracted texture features of the query image and those of the images in the database. Once all the distances are computed, the algorithm ranks the images of the database from the nearest to the furthest to the query image.

4. Experimental Results

The above proposed methods and the existing method are applied on more than 100 MRI images. The similarity measure values and the five retrieved images for the existing method, RTS and RTL are shown in the Figure 5, 6, and 7 respectively. The present method experimented RTL method with various Lag values. The high precision rate is achieved for a Lag value of 20, as shown in Figure 7.

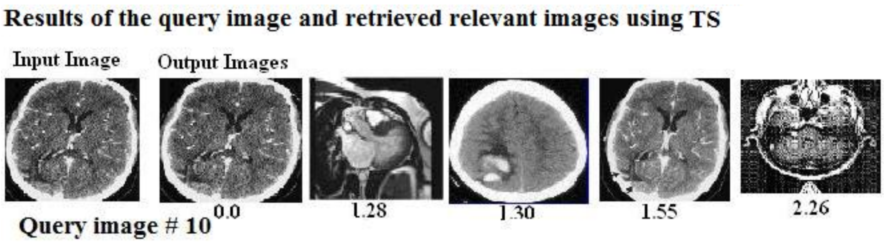

Figure 5. The results of the query image and retrieved relevant images using existing method

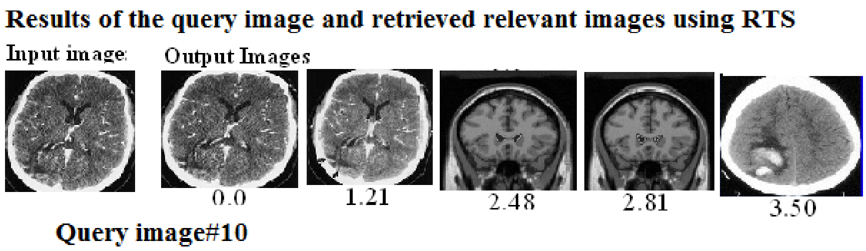

Figure 6. The results of the query image and five retrieved relevant images based on RTS

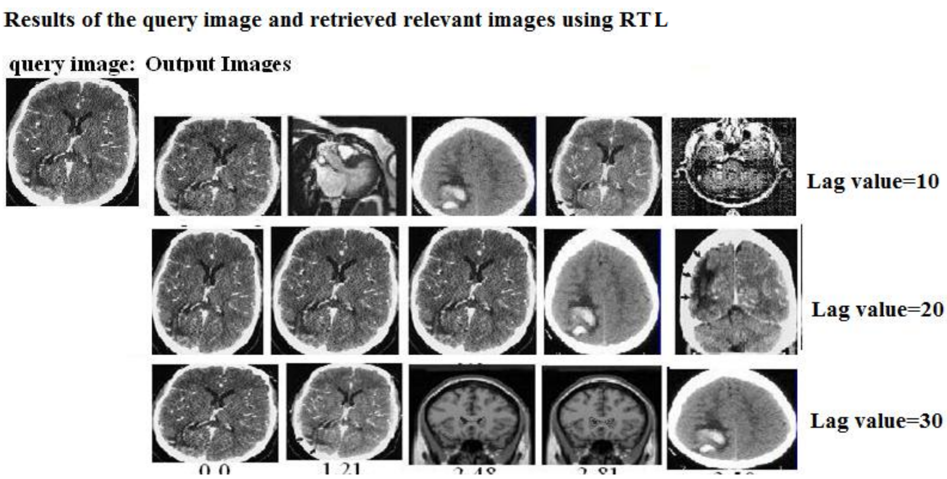

Figure 7. The results of the query image and five retrieved relevant images using RTL

The retrieval performance of different texture spectrum methods is shown in Table 1 and 2. The performance is measured based on the Precision rate of all the three methods considered and they are listed in the tables.

Table 1. Precision for TOP 5 and 10 images

Query image #10	TS	RTS	RTL		
			Lag value=10	Lag value=20	Lag value=30
5	2	2	2	3	2
10	4	5	4	7	4

Table 2. Precision for TOP 5 and 10 images

Query image #34	TS	RTS	RTL		
			Lag value=10	Lag value=20	Lag value=30
5	3	3	3	5	3
10	7	8	9	9	8

The Table 1and 2 clearly indicates the proposed method shows the similar results which are superior to other existing two methods.

The precision Vs the number of images returned for the query image using all the above three methods, for image #10 and #34 are plotted in the Figure 8 and 9 respectively.
From the Figure 8 and 9, it is clearly evident that the proposed RTL method outperforms the other two methods for all the Lag values considered. The RTL method with Lag value 20 performs better than, other two RTL methods with Lag value 10 and 30 respectively.

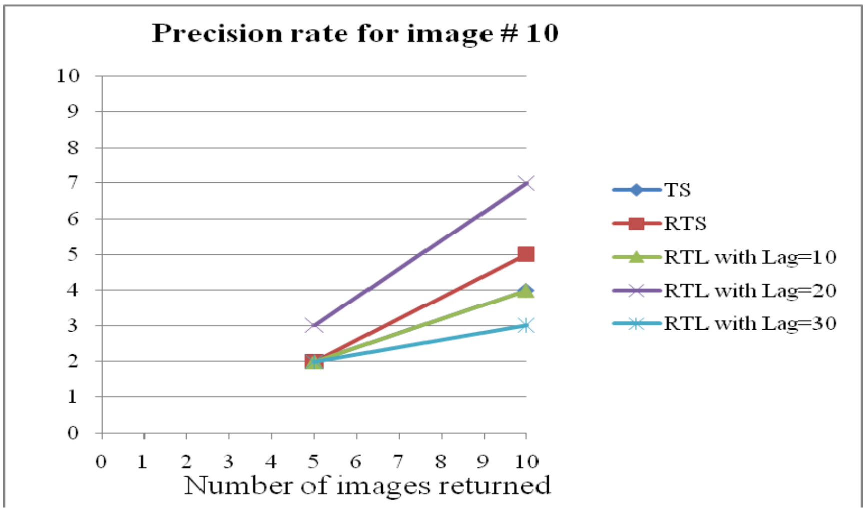

Figure 8. Precision Vs No. of Images returned for image #10

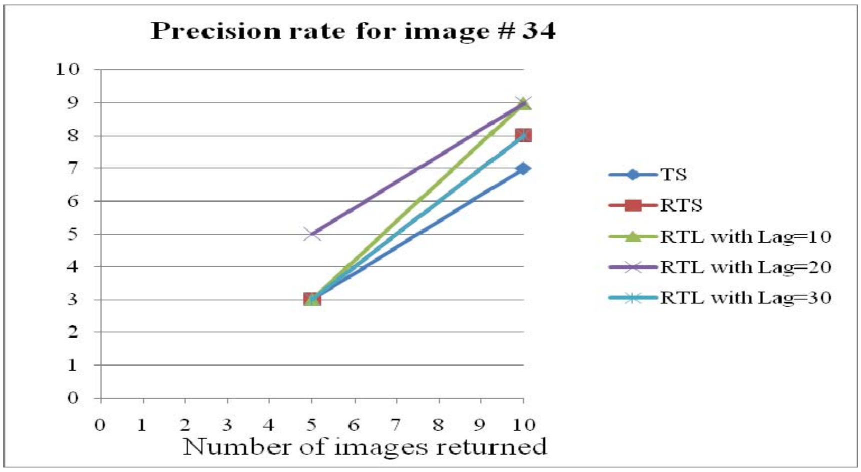

Figure 9. Precision Vs No. of Images returned for image #34

5. Conclusions

The present paper proposed a retrieval system based on a novel approach of Texture Unit. The proposed methods yield a high precision rate than the existing method. This reflects the fact that the proposed methods incorporate all local properties of the texture.

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