Comparison of Local Binary Pattern and Local Ternary Pattern for Classification of Arthritis in Knee X-Ray Images Using Euclidean Distance Method

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Abstract— **Arthritis is the most common inflammation in bone-joints and this progressive disease often leads to early disability and joint deformities. By the early diagnosis and treatment of the Arthritis, the damage to the joins can be reduced. A number of therapeutic approaches are now widely available for the diagnosis of this disease. Imaging of the affected joints plays a vital role in the diagnosis. In this paper, a novel classification system for the classification of OA in knee x-ray images based on Local Binary Pattern (LBP) and Local ternary pattern(LTP) is presented. The classification is achieved by extracting the histograms of LBP and LTP of the knee x-ray image. Then classifier system based on K Nearest Neighbor (KNN) is constructed. This system classifies the knee x-ray images into normal or abnormal, and the abnormal severity into medium or worst cases. 50 knee x-ray images are used to evaluate the proposed system. The classification rate achieved is very satisfied.**

Keywords— **Osteoarthritis, Knee X ray images, Local binary pattern, Local ternary pattern**

I. Introduction

The breakdown and eventual loss of the cartilage of one or more joints is called Osteoarthritis. The protein substance that serves as a "cushion" between the bones of the joints. There are a number of types of arthritis conditions, the most common type is osteoarthritis. Osteoarthritis occurs more frequently due to aging in human beings age. An infra red imaging camera is used to obtain accurate measurements of the erosions in bone joints affected by Rheumatoid arthritis in [1]. Temperature measurements of hands are analyzed with first order statistics and significant temperature differences between control subjects and patients for every joint and hand portion measured. Novel patient specific gait modifications that achieve knee OA rehabilitation without changing the foot path is proposed in [2]. The modified gait motion is designed for a single patient with knee Osteo arthritis using dynamic optimization of a patient specific full-body gait model. The algorithm developed using 3-D ground reaction force (GRF) provided an automatic computer method

to distinguish between asymptomatic and Osteo arthritis knee gait patterns in [3]. The coefficients of a polynomial expansion and the coefficients of wavelet decomposition are the two different features are investigated. A systematic computer aided image analysis method is used to analyze pairs of weight bearing knee x-rays in [4]. Image processing techniques like Histogram equalization, thresholding and edge detection applied on the Region of interest of the magnetic resonance images on knee segments cartilage from femur, tibia and menisc [5]. Machine vision systems for Osteo arthritis assessment in [6] is designed to help doctors to determine the region of interest of visual characteristics found in knee Osteo arthritis , and to provide accurate measurement of joint space width. Edge detection operator and its enhanced algorithm are used to detect edges for human knee osteoarthritis images in different critical situations in [7]. It is shown that the algorithm is very effective in case of noisy and blurs images. An image computing based method for quantitative analysis of continuous physiological processes that can be sensed by medical imaging and demonstrate its application to the analysis of morphological alterations of the bone structure which correlate with the progression of osteoarthritis is proposed in [8]. A fully automatic segmentation method of bone compartments in a knee joint on MR images from the osteoarthritis initiative a huge database for research on knee Osteo arthritis is proposed in [9].An automated technique for the visualization and mapping of articular cartilage in magnetic resonance images (MRI) is described in [10]. The main scope is towards developing an unique algorithm to provide an automated segmentation and mapping of thickness of articular cartilage from three-dimensional (3-D) gradient-echo Magnetic Resonance images of the knee joints. The method can also be used for assessment of changes in soft tissue engineered grafts. The change in synovial fluid in bone joints can be detected by using MRI imaging techniques[11].The data obtained by using Laser imaging on the affected joints when trained with Neural network provided better results for the diagnosis[12]. Radiographic methods provide a better results for the diagnosis of joint space narrowing   than   MRI[13].Moreover radiography is the conventional method followed for the detection of arthritis. The data from the digital X-ray images are more efficient to

analyze and compare than the image from the plain film X-Rays[14].In this paper, classification of arthritis in knee joints from the digital X-ray images, based on Local Binary Pattern(LBP),Local Ternary Pattern(LTP) and K-Nearest Neighbor (KNN) Classifier is presented. The paper is organized as follows. Section II describes the type of data taken for the analysis. The brief description of each block used to develop the proposed system is described in section III,IV and V. The proposed method is described in sections VI. The experimental results based on the proposed method are given in section VII. The proposed system for the classification of osteoarthritis in knee X-ray images is built based on extracting the data by using Local Binary pattern (LBP) and Local Ternary Pattern (LTP) and classifying the data by applying K-Nearest Neighbor (KNN) classifiers algorithm. In this following section the theoretical background of all the approaches are discussed.

II. Data

The Knee X-ray images used in this algorithm are obtained from three kinds of patients.The actual images are in Digital Imaging and Communications in Medicine (DICOM) fromat and they are converted into Joint Pictures Experts Group(JPEG) format.The images of the patients who has bearable pain and those who has no stiffness are considered as normal case. The images of the patients who has severe pain and little joint immobility are considered as medium cases and those patients who has very severe joint immobility are considered as worst cases. The medium and the worst cases are considered as the abnormal cases for the intial stage of classification which is discussed in section(vi).All those images were maually analysed and reported by a radiographer. These images were used to construct the training set for classification discussed in section(vi).The algorithm compares the features of the unknown input image with the features of the trained pre-stored data.

III. Description of Local Binary Pattern (LBP)

Local Binary Patterns (LBPs) are introduced by Ojala et al. [14] as a means of summarizing local gray-level structure. Around each pixel a binary valued local image pattern is formed. The original LBP operator works in a 3 x 3 window over an image. The pixels in this window are threshold by its center pixel value, multiplied by powers of two in clockwise or counter clockwise direction and then summed to obtain a pattern for the center pixel. Formally, the LBP operator takes the form

$$LBP(x_c, y_c) = \sum_{n=0}^{7} 2^n s(i_n - i_c) \qquad (1)$$

This process is applied for the whole image to obtain LBP of the given image. A 3x3 window size consists of 8-pixels, so that a total of $2^8 = 256$ different patterns can be obtained. Figure 1 shows the illustration of basic LBP operator
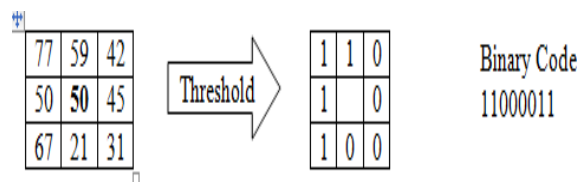

Figure.1. Illustration of basic LBP operator.

IV. Description of Local Ternary pattern (LTP)

Local ternary operator works over a 3X 3 window over the selected region of interest. Local ternary pattern uses a threshold constant to threshold pixels into three values whereas Local Binary Pattern uses only two values to threshold the pixels (either 0 or 1). The LTP operator can be expressed as

$$Sx = \begin{cases} 1 & if\ p > c + k \\ 0 & if\ p > c + k \\ & and \\ & p < c - k \\ -1 & if\ p < c - k \end{cases} \qquad (2)$$

Where
k -threshold value of the pixel
c- Center pixel value
p- Neighboring pixel value
From the expression (1), its clear that for each of the selected pixel value, any one of the value is obtained according to the deviation of the selected value from the threshold value. The neighboring pixels are combined after thersholding into ternary pattern. The histogram is computed for these ternary patterns. Each ternary pattern selected will comprise two binary patterns. The operation of LTP is illustrated as follows.
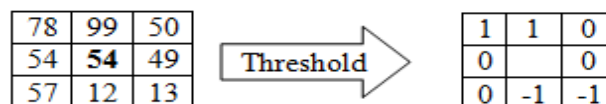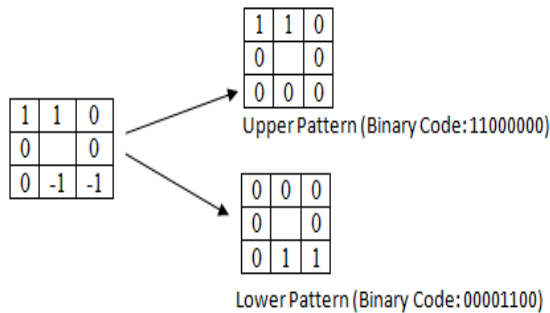

Ternary code generated 1100(-1)(-1)00

Figure.2. Operation of LTP operator

Figure 3 (a) Original Image

Figure 3 (b)ROI Image

V. Description of K-NN Classifier

The K-nearest neighbor algorithm (K-NN) is a method for classifies objects based on closest training examples in the feature space. This classifier is a type of instance-based learning and the function is approximated locally and all computation is deferred until classification. In K-NN, the classification is done based on the   majority vote of its neighbors. The object being assigned to the class most common among its k nearest neighbors (k is a positive integer, typically small). If K = 1, then the object is simply assigned to the class of its nearest neighbor. The neighbors are the set of objects for which the correct classification is known. This is taken as the training set for the algorithm, though it doesn't require any training steps.

VI. Proposed system

The proposed system for the classification of osteoarthritis in knee X- ray images mainly consists of two different stages which include the feature extraction stage and classification stage. The flow-diagram of the proposed system is shown in Figure. 5. All the stages involved in the flow diagram are explained in detail in the following sub sections

A. Feature Extraction Stage

Feature extraction involves simplifying the amount of resources required to describe a large set of data accurately. Analysis with a large number of variables generally requires a large amount of memory and computation power or a classification algorithm which over fits the training samples. Feature extraction is a term for methods of constructing combinations of the variables to get around these problems while still describing the data with sufficient accuracy.Figure. 4 shows the block diagram of feature extraction stage of the proposed system based on LBP and LTP is shown in Figure.5.
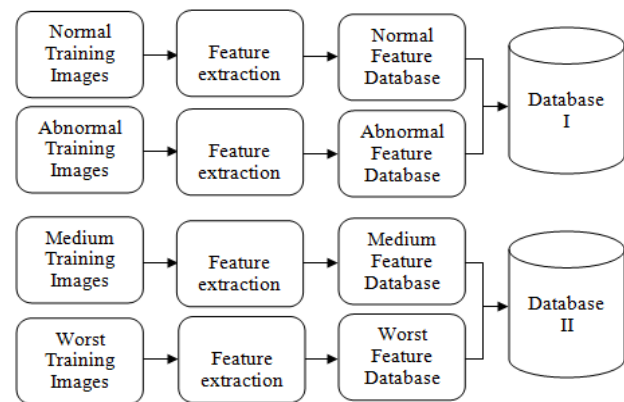

Figure .4 Block diagram of the feature extraction stage of the proposed system.

B. Classification Stage

 Classification phase executes two phases. In the Phase I, the classifier is applied to classify images of knee joints that is subjected to affected by osteoarthritis into normal and abnormal cases. Finally, the abnormal case is classified into medium or worst case in the final stage classification or Phase-II. In this classification stage, KNN classifier in every phase is trained at specific number of training set in each category. The block diagram of the classification stage of the proposed system based on KNN classifier is shown in Figure.5.

TABLE 1
NUMBER OF TRAINING SET AND TESTING SET FOR INITIAL STAGE CLASSIFIER

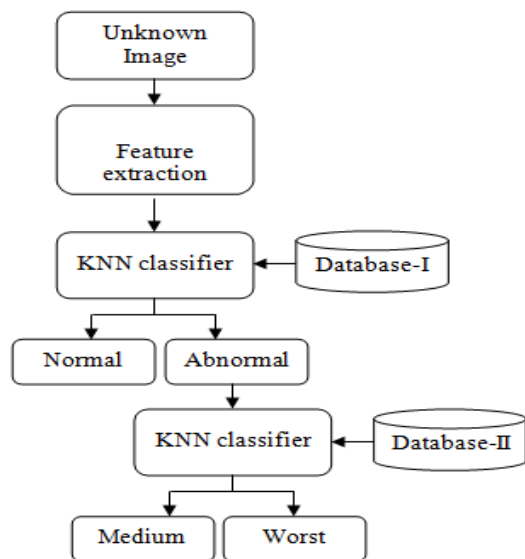| Type of Joint Spacing	No of training Images	No of Testing Images
Normal	10	15
Abnormal	20	35

Fig.5. Block diagram of the classification stage of the proposed system.

C. *Initial Stage Classifier*

In the initial stage classifier, manually extracted ROI from the knee X-ray image is tested for normal or abnormal category. Then the proposed feature, histogram of LBP is initially tested with the trained KNN classifier which uses DATABASE-I for classification. Table 1 shows the number of training and testing images used for the initial stage classifier.

D. *Final Stage Classifier*

In the final stage classifier, the abnormal ROI image from the initial stage classifier is further classified into Medium or Worst case. The extracted feature from the unknown ROI image is again tested with the trained KNN classifier which uses DATABASE-II. Table 2 shows the number of training and testing images used for the final stage classifier.

TABLE 2
NUMBER OF TRAINING SET AND TESTING SET FOR FINAL STAGE CLASSIFIER.

Type of Joint Spacing	No of training set	No of Testing set
Medium	10	16
Worst	10	19

VII. Experimental Results

To evaluate the performance of the proposed system, computer simulations and experiments with knee x-ray database images were performed. The performance of the proposed system is carried on 15 normal images and 35 abnormal images. Among the 35 abnormal images, there are 16 medium and 19 are worst case images. All the images are considered for the classification test. The distance measures used in the KNN classifier is Euclidean distance. The classification rate of proposed system obtained is shown in Table 3.

TABLE 3
CLASSIFICATION RESULTS OF PROPOSED METHOD

Type of Joint Spacing	Classification rate	
	LBP features	LTP features
Normal	71.43	86.67
Abnormal	91.43	91.43
Medium	93.75	87.50
Worst	99.74	78.95

VIII. Conclusion

A novel classification system for the classification of OA in knee x-ray images based on Local Binary Pattern (LBP) and Local ternary Pattern (LTP) is proposed. The extracted histogram of LBP and LTP of the knee x-ray image is used as features for the proposed system. The robust KNN classifier is used for the classification of knee x-ray images into normal or abnormal, as well as medium or worst cases. The proposed system is evaluated by using 50 images and the classification rate of the system based on Euclidean distance is tabulated. Local Ternary Pattern two binary patterns over the selected window whereas Local Binary Pattern generates a single binary pattern. This results in better classification rate with LTP over LBP for the initial stage classification ie. into normal and abnormal bone joint spacing. This can be observed from Table(3).On contrast it has provided unsatisfactory classification rate as compared to LBP for classifying medium and worst joint space width at the final stage classifier. The reason for this unsatisfactory classification is still under study. The performance of the proposed system can be evaluated by using different distance measure in the classifier which is considered as the future part of the work.

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