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Application of CART and IBL for Image Retrieval

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***Abstract*– In recent days there is an enormous growth in the storage of digital medical images in the databases. To access these images Content based image retrieval (CBIR) is used as an alternative to automated text based image retrieval approach. In CBIR the input query is in the form of medical image and retrieves diagnostic cases similar to it. To reduce the storage and transmission requirements of the medical images, Image compression techniques are utilized. In this paper, a method has been proposed which integrates image retrieval and compression techniques to minimize the bandwidth utilization. Loseless image compression is obtained using the Haar wavelet. Sobel edge detector and Gabor transforms have been employed for the extraction of the Edge and texture features from the compressed medical images. The classification is done using the Classification and regression tree (CART) and Instance based learner (IBL) and the accuracy obtained is 88% for the CART and 93% for IBL.**

***Index Terms*– Medical Images, Haar Wavelet, Sobel Edge detector, Gabor filter, Classification and Regression Trees and Instant Base Learner**

I. INTRODUCTION

THE development of digital imaging devices and the data storage capacity has led to the growth in medical images. The use of digital medical images has increased enormously over the few years for diagnosis. Retrieving the desired images from the database has become difficult. Content-based image retrieval (CBIR) is used as an alternative to automated text based image retrieval approach to overcome the problems of indexing in the traditional text based method [1]. CBIR uses automatically derived features such as color, texture and shape to classify and retrieve images.

In CBIR, the query is an image (Query by pictorial example (QBPE)) is a common retrieval method in the CBIR application [2]. Common CBIR algorithms are not efficient when applied to the medical images [3], [4]. To support medical tasks some new approaches have been developed for content based retrieval [5] but these are restricted for retrieval of tumor shapes in mammogram.

The storage of images in the databases takes huge amount of space and to transmit them requires bandwidth which is a challenging task nowadays. Image compression technique is a method to shrink the space required to store the images in the databases. These compressed images can be transmitted in lesser bandwidth [6]. For the next generation of the health care information infrastructure, the storage and analysis of the contents of medical digital images are essential. This infrastructure will help in sharing of health information among healthcare professionals and communities at large. In future, these services can be provided with the aid of emerging grid technologies and super computers.

Image compression is achieved by either lossy or lossless methods. Lossy compression methods are applied where minor loss of fidelity is acceptable. It is suitable for natural images such as photos where minor loss of information does not matter. Lossless compression methods are preferred for medical images or scans required for archival purposes. The lossy compression gives a high compression ratio compared to lossless compression. As information is an important concept in the medical images, lose of information while compression is not acceptable, hence lossless compression is employed. To satisfy the main motto of the compression the medical image, both the compression techniques lossy and lossless techniques are employed. Lossless compression is applied to the region of interest (ROI) by segmenting the part of the image where the information is crucial and lossy technique to the other remaining part.

In this paper, an investigation has been made to retrieve diagnosis cases similar to query medical image which are compressed for efficient storage and transmission. Image compression has been obtained using the Haar wavelet with a decomposition level of one to reduce the losses. The low level features edge and textures are extracted using Sobel edge detector and Gabor transforms from the compressed medical images. Classification and Regression Tree and Instance Based Learner are used for the classification accuracy of retrieved images.

II. RELATED WORK

In the last two decades there is a lot of research work is being done in CBIR system. In 1987, first theoretical CBIR systems design appeared [7] but the first prototype of CBIR system appeared in 1992 five years later and it was developed by T. Kato [8] for an electronic gallery containing 205 pictures of paintings. Later many changes have taken place in the CBIR systems. One of the major contributions for CBIR was the Internet boom and the arrival of the first internet browsers, which required tools to retrieve visual information. In medical field, CBIR is a powerful tool and is widely researched [9]. Many of the systems that were developed earlier used low level image features. Later some systems also utilized spatial organization of the image features such that similarity is determined. The spatial features use the information of the features absolute or relative location in the image [10]-[15].

A new learning algorithm in [16] described learning shapes, by memorizing property lists and updating associated weights during training process. To remove the useless property lists, a forgetting mechanism was used. A series of line segments are modeled by the shapes. The local spatial measures are calculated based on the orientations of these segments, and a property list for the shape is formed. An accuracy of 92% was obtained to classify tools and 96% was obtained for hand gestures. A real time system was built for face verification using simple correlation strategies based on the template models to identify a face in which the image is verified quickly [17]. Multi-Level Image Sampling and Transformation (MIST) methodology has been applied to natural scene segmentation. Three learning techniques were compared for classifying the natural scenes: AQ15c, AQ-NN and back propagation neural network. AQ-NN uses two different representations and learns using two different strategies. A predictive accuracy of 94% is achieved using AQ15c, while AQ-NN achieved 100% accuracy.

III. METHODOLOGY

A. Haar Wavelet

Generally images are transformed from space domain to local frequency domain. The Haar Transform (HT) transforms the image from the space domain to a local frequency domain [18]-[19]. The Haar wavelet operates on data by calculating the sum and the differences of the adjacent elements. It initially operates on the adjacent horizontal elements and on adjacent vertical elements. The Haar wavelet's mother wavelet function $\psi \; t$ can be given as:

$$\Psi(t) = \begin{cases} 1 & t \in \left[\frac{0,1}{2}\right) \\ -1 & t \in \left[\frac{1}{2,1}\right) \\ 0 & t \notin [0,1) \end{cases}$$

and the scaling function can ø(t) can be described as:

$$\phi(t) = \begin{cases} 1 & t \in [0,1) \\ 0 & t \notin [0,1) \end{cases}$$

Hilbert transform decomposes the signal into two components average (approximation) and details (fluctuation) are obtained. A signal having 2^n sample values, the first average sub signal $a^1 = a_1, a_2, ... a_{N/2}$ for a signal length of N is given as:

$$a_n = \frac{x_{2n-1} + x_{2n}}{\sqrt{2}}, n = 1,2,...., N/2$$

and the first detail sub signal $d^1 = d_1, d_2, ..., d_{N/2}$ is given as:

$$d_n = \frac{x_{2n-1} - x_{2n}}{\sqrt{2}}, n = 1,2,...., N/2$$

The transform is applied to all rows of the matrix. A resultant matrix of first level is formed by placing the approximation parts of each row transform in the first n columns and the corresponding detail parts in the last n columns. The resultant matrix has four pieces with each piece of dimension (number of rows/2) X (number of columns/2). Each piece is termed A, H, V and D. A is the approximation area, H is the horizontal area, V is vertical area and D is diagonal area [20].

$$M = \begin{bmatrix} t_{11} & t_{12} & \vdots & t_{13} & t_{14} \\ t_{21} & t_{22} & \vdots & t_{23} & t_{24} \\ \cdots & \cdots & \vdots & \cdots & \cdots \\ t_{31} & t_{32} & \vdots & t_{33} & t_{34} \\ t_{41} & t_{42} & \vdots & t_{43} & t_{44} \end{bmatrix}$$

$$A = \begin{pmatrix} t_{11} & t_{12} \\ t_{21} & t_{22} \end{pmatrix} \qquad H = \begin{pmatrix} t_{13} & t_{14} \\ t_{23} & t_{24} \end{pmatrix}$$

$$V = \begin{pmatrix} t_{31} & t_{32} \\ t_{41} & t_{42} \end{pmatrix} \qquad D = \begin{pmatrix} t_{43} & t_{44} \\ t_{53} & t_{54} \end{pmatrix}$$

B. Sobel Edge Detector

Edges are characterized by boundaries and are of fundamental importance in image processing. Using edge detection significantly reduces the amount of useless data and preserves the key structural properties of the image. Classical edge detection methods involve convolving image with an operator (a 2-D h filter), which is sensitive to the image's large gradients while returning zero value in uniform regions. Various edge detection operators are designed to be sensitive for certain edge types. In designing the edge detection operator variables a careful selection of Edge orientation, Noise environment and Edge structure are made. The sensitivity to edges is determined by the operator's geometry. Operators are trained to look for horizontal, vertical, or diagonal edges. Reduction of noise will lead to blurred /distorted edges so operators on noisy images are made larger so that it averages enough data to discredit localized noisy pixels. The Sobel Edge Detector generates a series of gradient magnitudes with a simple convolution kernel. The gradient of an image say f(x, y) at the location (x, y) is given by the vector

$$\nabla f = \begin{bmatrix} G_x \\ G_y \end{bmatrix} = \begin{bmatrix} \frac{\partial f}{\partial x} \\ \frac{\partial f}{\partial y} \end{bmatrix}$$

Employing the magnitude of the gradient vector in the edge direction, represented as **[**21]:

$$\nabla f = mag(\nabla f) = [G_x^2 + G_y^2]^{1/2}$$

The magnitude of the gradient is approximated as

$$\Delta f = |G_x| + |G_y|$$

and the direction of the gradient vector is given by:

$$\alpha(x, y) = \tan^{-1}\left[\frac{G_x}{G_y}\right]$$

where the angle is measured along the x-axis. The equivalent digital form of the gradient is given by Sobel operators and the equation is given by $G_x = (P_7 + 2P_8 + P_9) - (P_1 + 2P_2 + P_3)$ and similarly $G_y = (P_3 + 2P_6 + P_9) - (P_1 + 2P_4 + P_7)$ where P_1 to P_9 are the pixels in the sub image as shown in Figure 1 [22].

P_1	P_2	P_3
P_4	P_5	P_6
P_7	P_8	P_9

(a)

-1	-2	-1
0	0	0
1	2	1

(b)

-1	0	1
-2	0	2
-1	0	1

(c)

Fig. 1. Shows Sobel masks: (a) Sub image (b) Sobel mask for horizontal direction (c) Sobel mask for vertical direction

The masks in Figure 1 (b) computes Gx at the center of the 3X3 region and the other is used to compute Gy.

C. Gabor Filter

Gabor filters model texture for image interpretation tasks as there are strong relations between different filters outputs. The texture can be defined as the regular repetitions of an element or pattern on a surface. These relationships devise a new texture feature capable of describing texture information in a concisely manner. The Gabor filter consists of a tunable band pass filter and it also has a capability of multi-scale and multi-resolution. It has selectivity for orientation, spectral bandwidth and spatial extent. Visually different Image regions can have the same first order statistics. Use of second order statistics enables improvement of the situation taking into account not just grey pixel levels but also spatial relationships between them [23]. Gabor filter, Gabor transform are directed by the "Uncertainty Principle" [24]. This function provides accurate time-frequency location. A two dimensional Gabor function g(x, y) and its Fourier transform G(u, v) is given by:

$$g(x, y) = \left(\frac{1}{2\pi\sigma_x\sigma_y}\right) exp\left[-\frac{1}{2}\left(\left(\frac{x}{\sigma_x}\right)^2 + \left(\frac{y}{\sigma_y}\right)^2 + j\omega(x cos\theta + y sin\theta)\right)\right]$$

where σ is the spatial spread ω is the frequency θ is the orientation:

$$G\ u,v\ = \exp\left\{-\frac{1}{2}\left[\frac{u-W\ ^2}{\sigma_u^2} + \frac{v^2}{\sigma_v^2}\right]\right\}$$ Where $\sigma_u = 1/2\pi\sigma_x$ and $\sigma_v = 1/2\pi\sigma_y$.

D. Classification and Regression Trees

Decision tree approach is most useful in classification problem, in this technique a tree is built. Given a database D=$\{t_1, \dots \dots t_n\}$ where t_i= $\langle t_{i1}, \dots \dots, t_{ih} \rangle$ and the database schema contains the following attributes$\{A_1, A_2, \dots \dots A_h\}$. .CART (Classification and Regression Trees) developed by a group of statisticians [25] which describe the generation of binary decision tree. Entropy is used to choose the best splitting attribute and criterion. A best method of choosing the multiway partitions for CART was given in 1991 which chooses the best partition on the basis of statistical significance [26]. The splitting is performed around what is determined to be the best split point. At each step exhaustive search is performed to determine the best split. It is given by:

$$\Phi\left(\frac{s}{t}\right) = 2P_L P_R \sum_{j=1}^{m} [\ |P(C_j | t_L) - P(C_j | t_R)|\ ]$$

at t, the current node and each splitting attribute and criterion, s. L and R represent left and right subtrees of current node. PL, PR are the probability that a tuple in a training set will be on left or right side of a tree. This is defined as:

$$\left|\frac{\textit{tuples in subtrees}}{\textit{tuples in training set}}\right|$$

$P(C_j \mid t_L)$ or $P(C_j| t_R)$ is a probability that a tuple is in this class, Cj , and in the left or right subtree. This is defined as:

$$\left|\frac{\textit{tuples of class j in subtree}}{\textit{tuples at the target node}}\right|$$

At each step, only one criterion is chosen as the best over all possible criteria [27].

E. IBL Instance-Based Learning

Instance-based learning (IBL) is from a family of machine learning algorithms and it is also well-known as memory-based learning, and case-based learning [28]-[31]. IBL algorithms store the data and process the data only when a prediction is requested, thus, it is also called as a lazy learning method [32]. On the basis of the stored examples, Predictions are derived [33] accomplished by means of nearest-neighbor estimation principle [34]. Let X is equipped with a distance measure $\Delta(\cdot)$, i.e., Δ (x, x0) is the distance between instances x, x' $\in$ X. Usually Euclidean distance is used and attributes are normalized. Distance between two instances x_i and x_j is defined as:

$$d(x_i, x_j) \equiv \sqrt{\sum_{r=1}^{m} \left(a_r(x_i) - a_r(x_j)\right)^2}$$

Attribute are normalized by $a_r = \frac{v_r - \min v_r}{\max v_r - \min v_r}$ where v_r is the actual value of the attribute is the output space and $(x, y) \in X \times Y$ is called a labeled instance, a case, or an example. In classification, Y is a finite (usually small) set comprised of m classes $\{\lambda_1, \ldots, \lambda_m\}$, whereas Y = R in regression.

IBL reduces the number of training instances stored to a small set of representative examples. Another advantage of IBL is it can be used in problems other than classification.

IV. RESULTS AND DISCUSSION

Medical Images are compressed using the Haar wavelet. The low level features edge and textures are extracted using Sobel edge detector and Gabor transforms from the compressed medical images. The classification accuracy of retrieval is evaluated using CART (Classification and Regression Trees) and IBL (Instant Based Learning). Table 1 tabulates the classification accuracy and RMSE, and Fig. 2 shows the same.

Table 1: Classification Accuracy

Technique	Classification Accuracy	RMSE
Classification and Regression Tree	88%	0.3325
Instance Based Learner	93%	0.2646

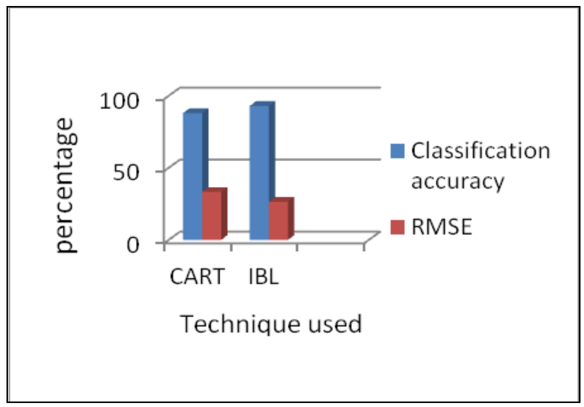

Fig. 2. Classification accuracy and RMSE for different techniques

Table 2 lists the precision, recall and f Measure for various classification techniques. Fig. 3 shows the precision and recall, Fig. 4 shows the f measure and Fig. 5 shows the Recall.

Table 2: Precision, Recall and F Measure

Technique	Precision	Recall	F-Measure
CART	0.913	0.84	0.875
IBL	0.957	0.9	0.928

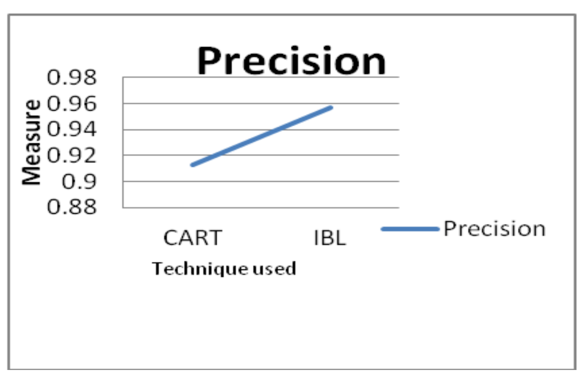

Fig. 3. Measured Precision

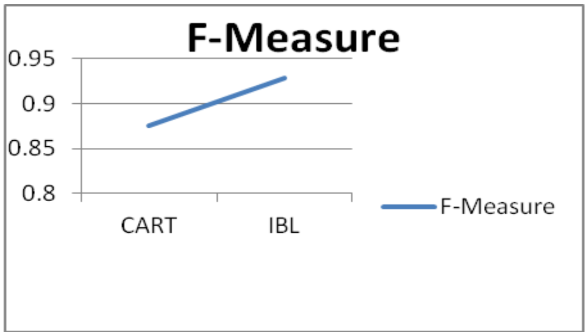

Fig. 4. f Measure

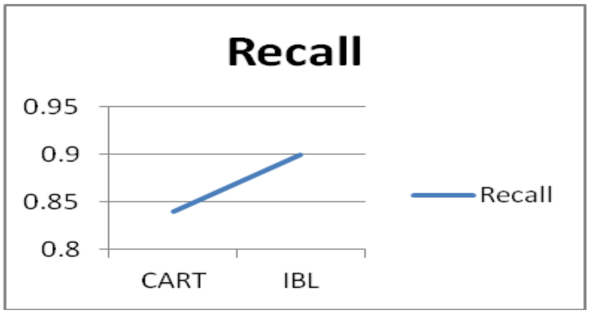

Fig. 5. Recall

V. CONCLUSION

In this paper, an investigation on image retrieval problem on compressed images is studied. For feature extraction on uncompressed images traditional techniques that are proposed in literature are extensively investigated. The classification accuracy obtained is comparable to the accuracies obtained in uncompressed images. Further work needs to be carried out to investigate the effectiveness of soft computing classification algorithms for compressed medical image retrieval.

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