AESS

Journal of Asian Scientific Research

journal homepage: http://aessweb.com/journal-detail.php?id=5003

LOSSLESS COMPRESSION OF FLUOROSCOPY MEDICAL IMAGES USING CORRELATION

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ABSTRACT

Medical institutions generate an enormous amount of medical images for examinations such as fluoroscopy, where each examination of a patient consists of a collection of images. This takes up a large amount of valuable storage space, in addition to the amount of time and cost incurred during transmission. Although lossy compression provides for better compression, lossless compression is usually required and expected for medical diagnosis. This paper proposes a new method for a lossless compression on oesophagus fluoroscopy images using correlation. The differences of pairs or sequence of images are classified based on correlation. From the experimental results obtained, the proposed method achieved improved performance with a compression ratio of 7.97 as compared to standard Huffman coding (HM) loss less compression.

Key Words: Fluoroscopy, ROI, Loss less image compression, Huffman coding, Correlation.

INTRODUCTION

Recent years have seen a tremendous increase in the generating, transmission and storage of medical images. Many researchers have been working towards developing approaches for compressing medical images.

Compression techniques can be classified into two main categories: lossless and lossy. Typically, lossless image compression is necessary for medical applications, where perfect accuracy is expected in maintaining the same quality of the original image for medical diagnosis. Nevertheless it comes at the expense of obtaining low compression ratios (Onsy 2007).

In lossy image compression, the reconstructed image is not identical to the genuine image but is usually reasonably close to it. The compression ratios achieved by lossy compression are higher.(FarshidSepehrband 2011).

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An important approach to improve the compression ratio (CR) and yet maintain the diagnostic quality of the image is to identify the region of interest (ROI). It is the diseased region where doctors should diagnose the abnormality, hence lossless compression would be applied. The rest of the image is then compressed using lossy techniques. Combining both techniques in this way provides higher CR while preserving the quality of the regions of interest (Onsy 2007).

Fluoroscopy is a special type of X-ray that provides continuous X-ray images of a patient's organ structures in a real time as individual radiographic. It is used in many types of examinations and procedures, such as Percutaneous Nephrostomy (PCN), Barium Swallow, cardiac catheterization, and others(Mei-Yen 2007).

In this paper, we investigate identifying the region of interest of esophagus fluoroscopy medical images and losslessly encoding it using Huffman coding(HM).Specifically, we propose a new framework for image compression based on images subtraction. To the best of our knowledge, there are no other published works employing this technique in the context of esophagus fluoroscopy medical image compression.

This paper is organized as follows: In section II, we briefly describe the fluoroscopy images, correlation, region of interest, and review related works. In section III, we define our new approach. In section IV, we present the experimental results and discussions, followed by the conclusion section V.

EXPERIMENTAL WORK

Identifying and extracting accurately the ROI is essential step before coding and compressing the image data for efficient transition or storage. By using different spatial regions and identifying the region of interest of the image, it is possible to compress it into different levels of reconstruction quality. Images can be classified into three regions: (1) Primary region of interest (PROI), (2) Secondary region of interest (SROI) and (3) background (Pervez Akhtar 2007).This way one could accurately maintain the features needed and transmit for medical diagnosis or for scientific measurement, while achieving high overall compression by allowing degeneration of data in the unimportant regions (Ravi kumar 2008).
The correlation was determined by the variance and co-variance, where the variance is measured for a dimension with itself, while the covariance is always measured between two matrices or dimensions. The formula of variance(Var) and co-variance (Cov)are given as(Muhammad YounusJaved 2008).

$$\mathrm{Var(X)} = \frac{\sum_i^n (X_i - \bar{X})(X_i - \bar{X})}{n-1} \qquad (1)$$

$$\mathrm{Cov(X,Y)} = \frac{\sum_i^n (X_i - \bar{X})(Y_i - \bar{Y})}{n-1} \qquad (2)$$

$$\mathrm{R}_{XY} = \frac{Cov(X,Y)}{Var(X)var(Y)} \qquad (3)$$

where $\bar{X}$and $\bar{Y}$ are means of X and Y respectively, R is the correlation between X and Y. To calculate the similarity between the orginal image and the reconstructed image, calculate the correlation coefficient(CC) as follows:-

$$\mathrm{CC} = \frac{\sum_s \sum_t [f(s,t) - \bar{f}(s,t)][w(x+s, y+t) - \bar{w}]}{\left\{\sum_s \sum_t [f(s,t) - \bar{f}(s,t)]^2 \sum_s \sum_t [w(x+s,y+t) - \bar{w}]^2\right\}^{1/2}} \quad (4)$$

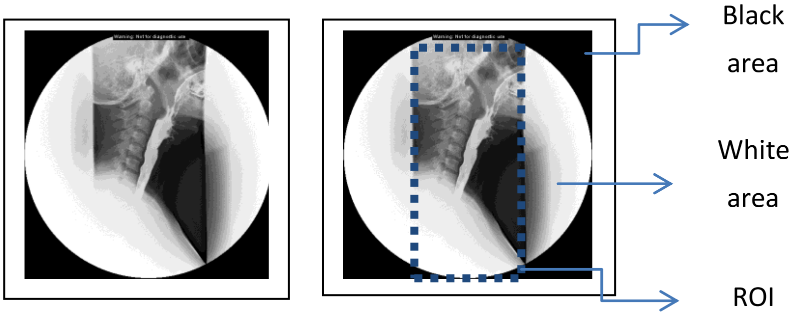
where x = 0, 1, 2,…, M-1, y = 0, 1, 2,…, N-1,$\bar{w}$is the average value of the pixels in w, $\bar{f}$is the average value of$f$(intensity function)in the region coincident with the current location of w, and the summations are taken over the coordinates common to both f and w, where M and N is the size of the original image. The CC is scaled in the range -1 to 1, independent of scale changes in the amplitude of f and w (Puja Bharti 2009).

PROPOSED METHOD

The proposed method is motivated by classifying the images depending on the CC, i.e. depending on the homogeneity between different images. This reduces the redundancy between images. Fig.1. give a sample of an esophagus fluoroscopy image used in this work, closely with the labels area to be processed. The diagram in Fig.2 summarizes the main steps involved in the proposed framework.

Figure-1. Sample of the Fluoroscopy image:

(a) Original image and (b) Label image



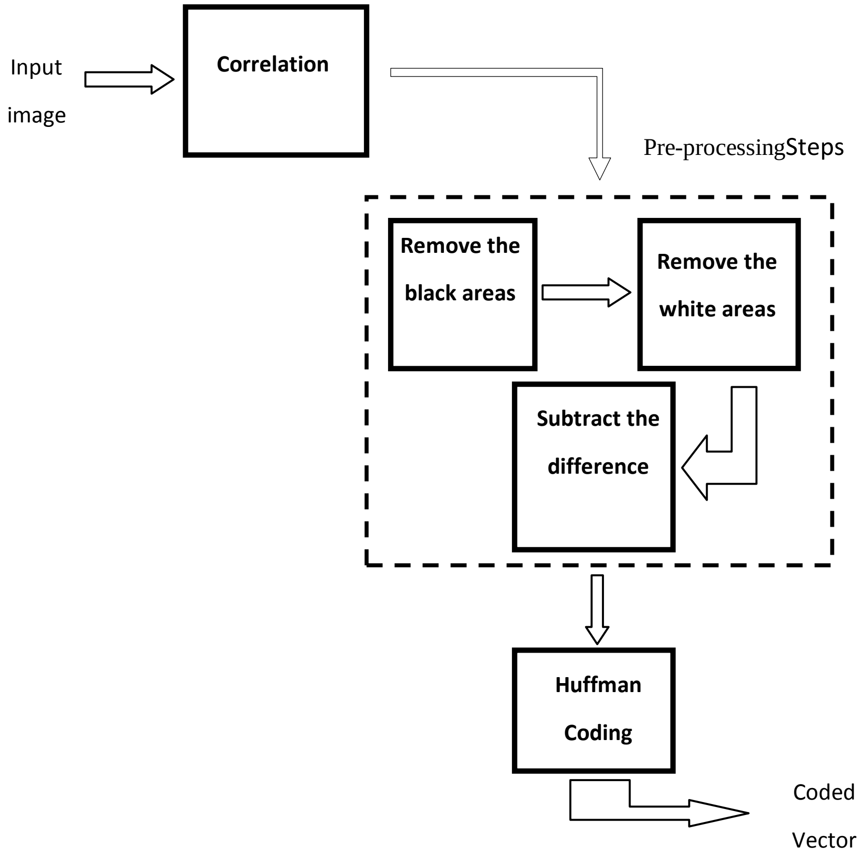
The proposed approach can be divided into three main steps:-

A- Correlation.

B- Preprocessing step.

C- Coding step.

Figure- 2. The framework of the proposed approach.



Classifying the images into groups according to the correlation value. Calculate the CC between the first image and the rest of the image collection as first step. In the second step calculate the CC between the second image and the rest of the image collection and so on.

The preprocessing step can be summarized as follows:-B-1 Remove the black areas from the fluoroscopy images. Depending on the appearance of the fluoroscopy images, there are four black angles surrounding each image. By determining the center of the image and calculating the distance from the center to the edge of the image, we can draw a circle that contains the actual data from the fluoroscopy device.

B-2Remove the white area from the fluoroscopy images. This does not contain any relevant data. Steps A1 – A2 result in the extraction of ROI.
B-3Compute the difference between images by subtracting the test image from the reference image, as most images taken from the same view are mostly similar. Therefore, we can use the first image as the base pattern and save the difference results as a vector.

Coding step. After preprocessing (step B), a one dimensional vector is obtained which will be used for coding. Depending on the structure of the vector data, we can decide the method of coding.

Huffman coding is selected because this coding method based on the estimated probability of occurrence for each possible value of the source symbol.

RESULTS AND DISCUSSION

We performed experiments on 100fluoroscopy images, each of size 512×512 pixels and file size of 256KB, to evaluate the validity of the proposed approach. The performance evaluation, in terms of CR depending on the CC is tabulated in Table1.The CC value is calculated as in (4),while the CR is calculated using the following:

$$\mathrm{CR} = \frac{S_o}{S_d} \tag{5}$$

where

S_o = File size of the original image,

S_d = File size of the difference image.

Table-1. Comparison of compression ratio performance (CR) between the proposed method (CM) and the standard method Huffman coding (HM) for a random sample of five images. [CC is the correlation between the tested and the reference images].

Reference Image	Tested Image	Correlation (CC)	Compression Ratio (CR)	
			CM	HM
14	15	0.98	7.97	1.12
14	24	0.94	7.88	1.16
17	29	0.82	6.39	1.15
17	25	0.80	6.25	1.16
14	23	0.78	3.97	1.16

Table 1 shows the correlation values between the tested and the reference images for a random sample of five images. The higher correlation is correlated with higher redundancy that will give higher compression ratio. From Table 1, it is also observed that the proposed method(CM) achieved significantly better performance than the standard lossless HM compression of the images. As an example, for images 14 and 15, the standard method only produced CR of 1.12. With the proposed method (CM) implemented based on the CC indications, a CR of 7.97 was achieved for the difference image (14-15). Assuming that image 14 was stored in the standard method, the improvement in CR for storing the vital information of image 15 losslessly improved from 1.12 to 7.97, which is a very significant 700% improvement. To further evaluate the performance gain, the benefits in terms of storage and transmission should be studied. Table 2 lists the total size of a random group sample(ten test fluoroscopy images), against the size of the images compressed using the proposed method. It is observed that the total transmission size of the proposed method is only 29% of that of the original images, indicating significant transmission time and cost reduction.

Table- 2. Total sizes of ten fluoroscopy images against the size of the images compressed using the proposed method.

No. of images	Original	Proposed method
10	2560KB	749.62KB

CONCLUSION

In this paper, a new framework for image compression based on the grouping the images based on the correlation has been proposed. The technique concentrates on the region of interest to code the difference between the groups of images using Huffman coding. The method has been shown tobe able to achieve significant improvement in compression performance, and indirectly storage and transmission benefits. Our proposed framework is not coding specific, we would like to implement other lossless coding techniques such as Run Length Coding (RLE) and Golomb-rice coding in order to further improve the compression performance.

ACKNOWLEDGEMENT

The authors would like to thank Dr.Noraini Abdul. Rahim(head radiology department), KhatijahAli(radiographer) and MrAng Kim Liong(clinical research centre)in Serdang Hospital.

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