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HYBRID COMPRESSION OF CERVICAL IMAGES BY SEGMENTING NUCLEI-CYTOPLASM

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Abstract

A hybrid image compression method is proposed by which the Nuclei-Cytoplasm of the image is completely restorable and the background part of the image is restorable with insignificant loss. In Hybrid Compression of Cervical Images by Segmenting Nuclei-Cytoplasm, the image is subjected to binary segmentation to detect Background and Nuclei-Cytoplasm. The image is compressed by standard lossy compression method. The difference between the lossy image and the original image is computed as residue. The residue at the Nuclei-Cytoplasm area is compressed by standard lossless compression method by which the Nuclei-Cytoplasm area is completely restorable. This method gives a low bit rate than the lossless compression methods.

Keywords:

Edge Detection, Segmentation, Image Compression

1. INTRODUCTION

Medical Image processing is developing in an exponential way as it is very well used in diagnosis of deceases. Large amount of space is required to store these images. Image compression is one of the solutions to handle these requirements. Medical Images are analyzed to identify different types of cancers. In order to diagnose cervical cancer, the cervical cells are analyzed by measuring the size of Cytoplasm and Nuclei. Various image segmentation algorithms are devised to separate nuclei region and cytoplasm region in the cell. These segmentation methods can be adopted in hybrid image compression, where the image is compressed after segmenting Nuclei-Cytoplasm and background region of the image. Image compression can be classified as lossless and lossy[4] compression. Lossless image compression methods have the ability to reconstruct the exact replica of the original image with no distortion. In lossy compression the exact replica of the original image may not be reconstructed. Vector quantization [11], [14], wavelet transformation [1], [3], [8], [13], [17], [21] are commonly used techniques in addition to various other methods[18] in image compression. The lossless compression results in very low compression ratio. The lossy compression results in high compression ratio but may slack important details of the image. Hybrid image compression [6], [22] methods incorporated different compression schemes like PVQ and DCTVQ in a single image compression. But the proposed method sketches the framework to use lossless and lossy compression methods to compress a single image.

The proposed method performs a hybrid compression, which makes a balance on compression ratio and image quality by preserving the important details. In this approach the Nuclei-Cytoplasm in the image is very important than the background image. Considering the importance of image components, and the effect of smoothness in image compression, this method segments the image as Nuclei-Cytoplasm and background, then the background of the image is subjected to lossy compression and the Nuclei-Cytoplasm is kept unaffected. There are enormous amount of work on image compression is carried out both in lossless [1],[15],[20] and lossy [5],[7],[11],[13],[16],[17] compression. Very few works are carried out for Hybrid Image compression [22]-[23].

In the proposed work, for image compression, the edge detection, segmentation, smoothing and dilation techniques are used. For edge detection, segmentation [9], smoothing and dilation, there are lots of work has been carried out [19]. A simple and a time efficient method to detect edges and segmentation used in the proposed work are described in section 2, section 3 gives a detailed description of the proposed method, the results and discussion are given in section 4 and the concluding remarks are given in section 5.

2. BACKGROUND

Let, X be a two dimensional array of order m x n, represents the image of width m and height n. The range of values for $X_{i,j}$ is [0,255], for any i = 1,…..m, any j = 1,.....n. G be a two dimensional array of the same order as of X for holding the gradient value, with a range of values [0,255]. E be a binary matrix of the same order as of X and holding the status of the pixel if it is in edge or not, having the range of values [0, 1].

2.1 EDGE DETECTION

The edge detection is performed by following few steps. Initially the maximum gradient value of a pixel is found from its three neighboring pixels as shown in Fig.1. Then the maximum value of the gradients is checked to satisfy the precondition then the corresponding pixel is considered to be in edge. The process to detect whether a pixel $X_{i,j}$ at (i, j) is in edge or not can be formally represented as Eqs.(1) and (2).

$X_{i,j}$	$X_{i+1,j}$
$X_{i,j+1}$	$X_{i+1,j+1}$

Fig.1. Neighboring Pixels

$$G_{i,j}=\max\{|X_{i,j}-X_{i+1,j}|,|X_{i,j}-X_{i+1,j+1}|,|X_{i,j}-X_{i,j+1}|\} \quad (1)$$

$$E_{ij}=\begin{cases}1 & \text{if } G_{ij}>\tau \\ 0 & \text{otherwise}\end{cases} \quad (2)$$

where, τ is a predefined threshold value. Here a threshold value is selected empirically, and the precondition to a pixel $X_{i,j}$ at (i,j) to be in edge is that the value of $G_{i,j}$ should be greater than the threshold, otherwise the pixel is said to be in non-edge area.

2.2 SEGMENTATION

The segmentation of foreground and background image is processed after identifying the edges according to section 2.1. The scan line algorithm is applied to fill in the area bounded by the edges. The horizontal and vertical scanning is applied independently and the results are combined to get the foreground region image. In horizontal scan line process, the scanning starts from left to right to find non-zero value in the edge matrix E. For scanning line or row j, the column i varies from 1 towards n, and checks for non-zero value in $E_{i,j}$, once non zero $E_{i,j}$ is found, set starting column 'is' as i, now the scan proceeds from right to left to find the right most edge pixel, the column starts from n towards 1 to find a non-zero element at row j once nonzero E_{ij} is found, set ending column 'ie' as i. Now fill the line $E_{is,j}$ to $E_{ie,j}$. After repeating the process for all the rows in the image, the horizontally filled image will be ready, similarly vertical scan line process starts from top to bottom that is keeping the column fixed and change the row from 1 to m. After completing vertical scan line process, the two images are combined by logical AND operation. The resultant image is a binary image where the foreground is represented by 1 and the background is represented by 0. The segmented image is used in the proposed algorithm to decide whether to preserve a pixel or not. A circler structural element is used to perform morphological closing to get rid of irregular border.

2.3 BIGROUP METHOD

Each pixel in the input image is replaced with lower average or higher average based on the neighborhood of the pixel as follows. A set of neighboring pixels from a window of order $w \times w$ is selected around the pixel. The set of pixels are sorted in ascending order based on the intensity level. The ordered vector is divided into two groups as lower valued and higher valued groups based on the middle value. The group average is computed and the pixel is classified to lower group if its value is less than the lower group's mean value. If the pixel value is higher than upper group's mean value then it is classified to upper group.

3. PROPOSED HYBRID IMAGE COMPRESSION METHOD

Hybrid Compression of Cervical Images by Segmenting Nuclei-Cytoplasm (HCCISN) method compresses the image with inconsequential loss in background of the image and with no loss in the Nuclei-Cytoplasm region of the image. In order to compress the image, initially the input image is smoothed by a mean filter. Then the input image is segmented (α) into Nuclei-Cytoplasm and background image as described in section 2. The segmented image (β) is a binary image as described in section 2.2. The Near Lossless compressed image (λ) is created by compressing the Nuclei-Cytoplasm region of original input image by standard compression method. Then a lossy background image (δ_c) is computed by lossy compressed image at background area. The λ and δ_c are stored which are used to formulate the hybrid image($\hbar$). The compression ratio is expected to be comparatively better than lossless image compression and the image quality is to better than lossy compression. More details are discussed in section 4. The block diagram in Fig.2 gives the overall picture of this method. The entire operation in HCCISN can be written in steps as follows:

Step 1: Read the input image (α)

Step 2: Find Nuclei-Cytoplasm (β) and background δ

Step 3: Near Lossless compress β to get λ

Step 4: Lossy compress δ to get δ_c

Step 5: Store λ and δ_c to get the hybrid image ($\hbar$).

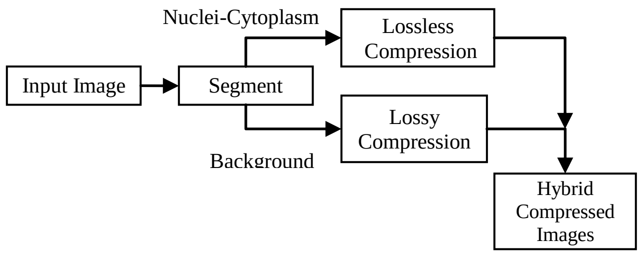


Fig.2. Block Diagram of HCCISN

The decompression is the reverse of the above operations. Initially all the compressed components λ and δ_c are restored from compressed file. The near lossless image λ is decompressed; the lossy background can be restored from δ_c. The hybrid image can be formed by combining Nuclei-Cytoplasm area with the lossy image. The Nuclei-Cytoplasm region can be extracted using following steps,

Step 1: Smooth input image (α) by Gaussian filter.

Step 2: Apply bi-group method to smoothed image.

Step 3: Extract nuclei by threshold bi-group image.

Step 4: Eliminate Non-Nuclei by checking roundness.

Step 5: Find Cytoplasm.

Step 6: Merge Nuclei and Cytoplasm.

The results obtained over the test runs of the algorithm are discussed in section 4.

4. RESULTS AND DISCUSSION

The HCCISN method is implemented according to the description in section 3 and tested with a set of images. The results obtained from the implementation of the proposed algorithms are shown in Fig.3, Fig.4 and Fig.5. The compressed hybrid image by HCCISN is shown in Fig.4(i). Fig.4(a) shows the original input image, Fig.4(b) shows the smoothed image of Fig.4(a). Fig.4(c) shows the impact of bi-grouping. In Fig.4(d) the white area shows the detected Nuclei area. From Fig.4(e) the gradient of the entire image can be observed. Fig.4(f) shows the cytoplasm region. It can be observed from Fig.4(i) and Fig.4(h) that there is no difference in hybrid image from input image at

Nuclei-Cytoplasm area. This indicates that there is no significant loss at Nuclei-Cytoplasm area. There is small difference in the area other than Nuclei-Cytoplasm area can be observed. The compression ratio achieved by the proposed method is shown in Fig.3. It can be observed that the proposed method gives improved compression ratio for all the test images. Fig.5 shows the PSNR qualitative metric observed for the proposed method which is lower than near lossless compression method.

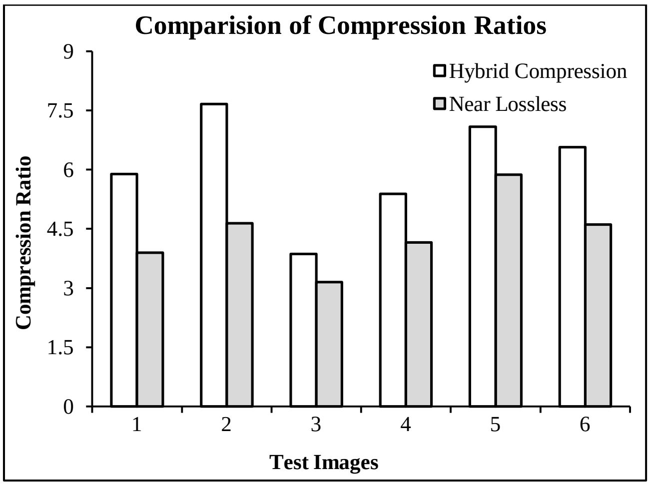
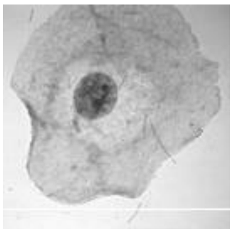
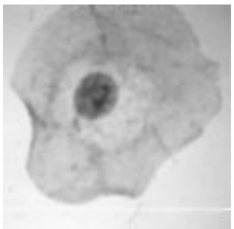


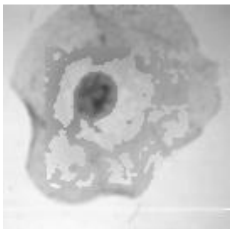
Fig.3. Compression Ratio Vs Compression Methods for different Images



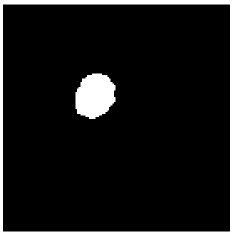
(a) Input Image



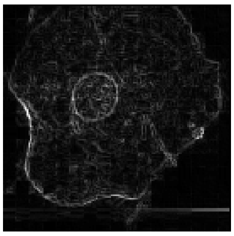
(b) Smooth Image



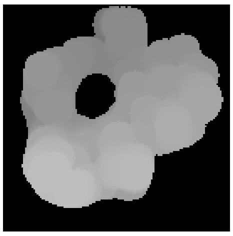
(c) Bi-group Image



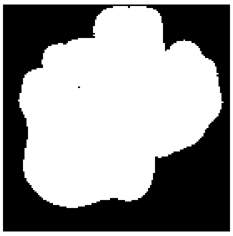
(d) Segmented Nucleus Area



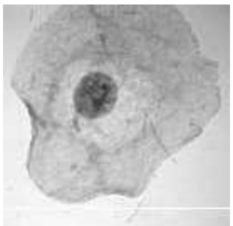
(e) Gradient Image



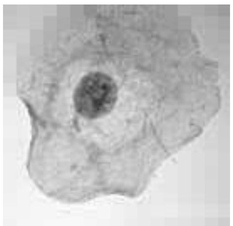
(f) Cytoplasm Area



(g) Nucleus-Cytoplasm Area



(h) Decompressed Image (Existing Method)



(i) Decompressed Image (Proposed)

Fig.4. Input and output images

5. CONCLUSION

In HCCISN, the compression ratio is higher than near lossless compression and quality is higher than lossy compression methods. The computation time is higher because of the overhead of segmenting Nuclei-Cytoplasm. The compression ratio depends on the percentage of area of the Nuclei-Cytoplasm of the image. As the area increases the compression ratio decreases since the numbers of pixels to be stored in near lossless mode are increased.

Since the Nuclei-Cytoplasm part of the image is preserved, these compression methods can be well suited for any kind of image data store which compresses images offline. Improved segmentation and near lossless compression methods may be incorporated in future to get better results.

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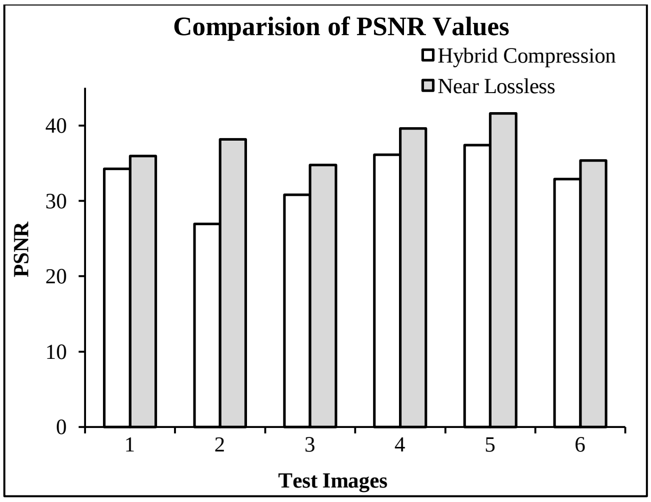

Fig.5. PSNR vs. Compression Methods for different Images

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