Improved Block Based Segmentation and Compression Techniques for Compound Images

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Abstract— **Image compression is to minimize the size in bytes of a graphics file without degrading the quality of the image to an unacceptable level. The compound image compression normally based on three classification methods that is object based, layer based and block based. This paper presents two techniques under block-based classification. After a brief introduction of the classification methods, two methods were enhanced and results were evaluated. The performance metrics Compression radio, PSNR, Compression and Decompression time are tested for both the models.**

Keywords- Compound Image, Block based segmentation, Image compression, Histogram based, AC-Coefficient based.

1. Introduction

Documents in digital form play an important role in day-to-day life. A range of document imaging applications such as scan-to-print, document archiving, internet fax, and internet browsing are driving the need for document compression standards that maintain high quality while achieving high compression ratios [1]. The problem of compound image compression arises from various applications related to the storage and the distribution of document images. The main goal of compound image analysis is to recognize the various components or regions of an image and incorporate compression that is appropriate for each region. The compound image compression is differing from natural image because it is a combination of text, line arts and pictures [2]. The quality requirement of compound image coding is different from general image coding because users cannot accept the quality if the text is not clear enough to recognize [3].

This paper is organized as follows: In section 1 the brief introduction of compound image compression is provided. Section 2 discuss about the overview of compound image compression. Section 3 has the review of block based segmentation. Section 4 discusses in detail about the compression techniques. Section 5 discuss about the experimental results of the two models. Finally the section 6 concludes the paper.

2. Compound Image classification Techniques

Compression of a compound image is more critical than natural image. Basically a compound image is a combination of text, graphics and pictures. Most methods use different algorithms for various functionalities. Compound image compression normally based on the following categories.

1.Object Based

2.Layer Based and

3.Block Based

Most of the recent researches in this field mainly based on either layer based or block based. In object based method a page is divided into regions, where each region follows exact object boundaries. An object may be a photograph, a graphical object, a letter, etc. The main drawback of this method is its complexity.

In layer-based method, a page is divided into rectangular layers. Most of the Layer based methods follow the 3-layer MRC model. The basic three layers MRC model represents a color image as two color-image layers

[Foreground (FG), Background (BG), and a binary Mask layer (mask)]. The mask layer describes how to reconstruct the final image from the FG/BG layers.

In the block-based method a page is divided into rectangular blocks where each block follows exact object boundaries. The advantages of this approach are simplified segmentation, better match between region boundaries and the compression algorithms, and the lack of redundancy. In this paper, two block based techniques are enhanced for compression of compound images. The following section 3 discuss in detail about the block based segmentation technique.

3. Block Based Segmentation

This approach divides an image into blocks of regions. Each region follows approximate object boundaries, and is made of rectangular blocks. The size of the blocks may vary within the same region to better approximate the actual object boundary. Block-based segmentation algorithms are developed mostly for grayscale or color compound images. For example, [4] proposed a method based on the absolute values of Discrete Cosine Transform (DCT) coefficients, and [5] use a DCT block activity measure. In [6], text and line graphics are extracted from check images. In [7] propose a classification algorithm, based on the threshold of the number of colors in each block. [8] Proposed a technique called the Run Length-Smoothing Algorithm (RLSA) to partition a binary compound image into blocks. A similar algorithm was also investigated by [9] for newspaper layout analysis. [10] Enhanced the above algorithm by including a recursive block partition algorithm based on RLSA. The work is extended and a technique is proposed for compressing compound images as well as videos [11]. The following figure1 shows the block based segmentation process.

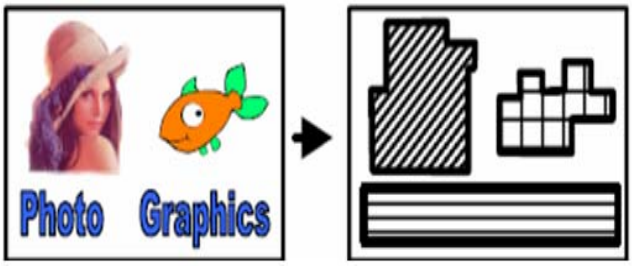

Figure1 Block Based Segmentation

The following sub sections discuss the two models in block based segmentation.

3.1. AC-Coefficient Based Model

The first model uses the AC coefficients introduced during DCT to segment the image into three blocks, background, text/graphic and image blocks [12]. The background block has smooth regions of the image while the text / graphics block has high density of sharp edges regions and image block has the non-smooth part of the compound image. AC energy is calculated from AC coefficients and is combined with a user-defined threshold to identify the background block initially. The AC energy of a block ‘s’ is calculated using Equation (1).

$$E_s = \sum_{i=1}^{63} Y_{s,i}^2 \qquad (1)$$

where $Y_{s,i}$ is the estimate of the i-th DCT coefficient of the block ‘s’, produced by JPEG decompression. When the E_s value thus calculated is lesser than a threshold T_1, then it is grouped as smooth region else it is grouped as non-smooth region.Next, from the luminance value, the feature vectors from the rest of the blocks are extracted and collected. From this, the non-smooth block is classified into two classes, text and image, using k-means clustering algorithm. Different algorithms are then used to compress the three regions of a compound image. The following figure 2 shows the overall design of AC-coefficient model.

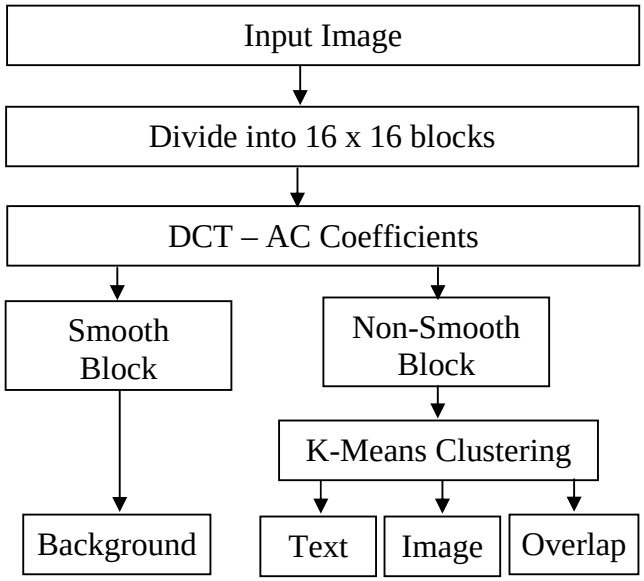

Figure 2 AC-Coefficient Based Segmentation

3.2. Histogram Based Model

The second block-based segmentation model uses a histogram-based threshold approach [13]. This model uses a series of decision rules to segment an image. The existing segmentation classifies an image into four regions, which is modified into five regions. The decision rules are modified to include an extra rule with other threshold to handle the fifth region, which is called the residue or overlapping or complex region. This region in the existing model was treated as a picture block, but in reality might have text and/or graphics and/or picture regions. This has to be separated from the picture block, so that the compression of picture block will be enhanced. And special treatment of overlapping block might enhance both segmentation and compression processes.

The segmentation process involves a series of decision rules from the block type with the highest priority to the block type with the lowest priority. The decision for smooth and text blocks is relatively straightforward. The histogram of smooth or text blocks is typically dominated by one or two intensity values (modes). Separating the graphics and image blocks is challenging. Since the maximum size of color palette in color indexing strategy is four, a block is declared to be a graphics block only if the number of modes is no larger than four. When the block size is reasonably small, the likelihood that there are more than four different colors within a graphics block is small.

The algorithm starts by calculating the probability of intensity value i, where i = 0... 255 using Equation (2)

$$p_i = freq(i) / B^2 \qquad (2)$$

Where B is the block size and a value of 16 is used in the experiments. Next the mode (m1… mx) is calculated and the cumulative probability around the mode m is computed using Equation (3).

$$c_n = \sum_{m-A}^{m+A} p_i \qquad (3)$$

The following section 4 deals with the compression techniques.

4. Compression Techniques

The process of compression is resolved using a 2-step process, that is, segmentation and compression. The result of segmentation is a set of non-overlapping coherent regions, whose union reproduces the entire original image. These regions are then compressed using techniques, which are either existing or newly proposed. The image is segmented into regions listed below.

- The smooth (background/foreground/one colored) regions
- The text region
- The picture or image region
- The graphics region
- The overlapping region

The smooth and graphics regions are compressed using arithmetic coder and palette-based coder respectively. The text region is compressed using the XML coder, Token based coder [14] and the image, overlapping regions are compressed using the modified JPEG coder.

5. Experimental Results

The following Figure 3 is the combination of all classes of compound images, which are used for testing.

Computer Generated Image (CGI) | **Text Images (TI)** | **Scanned Image (SI)** | **Document Image (DI)**

Figure 3 Test Images

To assess the performance of the proposed models the three standard performance metrics used are

(i) Compression Radio
(ii) Peak Signal to Noise Radio
(iii) Compression Time And Decompression Time

The compression ratio is calculated using the below formula, which is shown in equation (4).

Compression Ratio =1 – (Compressed size / Original size)*100 (4)

The Table 1 shows the compression ratio of the two proposed methods.

Table I Compression Ratio(%)

Image	JPEG	DjVu	AC-Coefficient Based	Histogram Based
CGI	39.38	40.25	45.77	45.12
TI	38.77	42.13	46.04	46.38
SI	38.56	45.55	49.23	49.21
DI	39.46	43.91	46.89	47.29

From the above Table I results, the two models gain high compression ratio. For computer generated and scanned image the AC co-efficient method achieves good Compression ratio. For text and document image the histogram based method achieves good compression ratio.

The peak signal to noise ratio is used to measure the visual quality of the image. The high PSNR indicates the decompressed image have good quality. The Peak Signal To Noise Ratio is calculated using the formula,

$$PSNR = 10 \cdot \log_{10} \left(\frac{MAX_I^2}{MSE} \right)$$

The Table –II shows the results of PSNR The high PSNR indicates high quality of the image.

Table-II Peak Signal to Noise Ratio(%)

Method Used	CGI	TI	SI	DI
JPEG	40.37	43.92	41.52	40..88
DjVu	44.66	46.33	45.92	43.92
AC-Coefficient Based	47.46	47.92	47.20	45.26
Histogram Based	48.23	48.18	47.95	45.93

Compression and decompression time denotes the time taken for the algorithm to perform the encoding and decoding algorithm respectively. The compression time and decompression time of the two proposed methods are shown in Table III.

Table III Compression & Decompression Time (Seconds)

	JPEG		DjVu		AC-Coefficient Based		Histogram Based	
Image	CT	DT	CT	DT	CT	DT	CT	DT
CGI	0.77	0.93	0.69	0.91	0.88	0.91	0.69	0.88
TI	0.91	0.36	0.86	0.31	0.88	0.86	0.84	0.77
SI	0.81	0.69	0.89	0.62	0.88	0.83	0.84	0.63
DI	0.74	0.91	0.69	0.85	0.70	0.83	0.67	0.63

Compared with AC-Coefficient based method the Histogram method achieves compression in a minimum period of time.

6. Conclusion

This paper attempts to enhance two block based segmentation methods .The performance of the histogram based method and AC-Coefficient based method are compared with compression ratio, PSNR, compression time and decompression time. From the performance analysis the histogram based segmentation method achieves good results compared with AC-Coefficient method.

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