Region Based Hybrid Wavelet Coding of Passport Photographs

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Abstract - *This paper deals with an image compression system for head and shoulder images which are used in photo identity cards for personal identification. The proposed Region Based Hybrid Wavelet Coding (RBHWC) method splits the images into four regions depending on their importance in recognition. Applying different wavelets and coding methods for different regions, it is possible to achieve good compression performance. The results are compared with the existing Hybrid Wavelet Based System (HWCS) and it is observed that the proposed method gives better compression.*

Keywords : hybrid wavelet coding, region splitting, head and shoulder image

1.0 Introduction

Digital passport size photographs affixed identity cards are popular for the purpose of identifying persons. Enormous number of photographs has to be stored in many applications and saving one or two bytes in the storage of a single photographs results in a gain of several mega bytes. So improvements in image compression algorithms have got significance in this area.

H.Chung et.al. studied passport size photo compression using wavelets and neural networks for recognizing important face features. They have shown that finer outputs could be produced only in 86% of cases even though they attain a compression ratio of 200:1 [1]. The HWCS [2] system has been shown to offer an additional 20% savings while maintaining an acceptable output image quality.

Passport size photos include a background and head and shoulder regions. The key idea in the proposed scheme is to use different coding schemes for different areas of the image so as to optimize ratio of compression and quality of the reconstructed image. The image is divided into four regions of interest namely, Head (most important feature), neck (less important features), left shoulder and right shoulder (least important features). To achieve better compression performance, four regions are preprocessed and coded differently. Selection of preprocessing method and filters is based on the importance of regions in recognition.

2.0 Theoretical Background

2.1 Wavelet Theory

Wavelet transform represents an image as a sum of wavelet functions with different locations and scales [3]. Any decomposition of an image into wavelets involves a pair of waveforms: one to represent the high frequencies corresponding to the detailed parts of an image and one for the low frequencies or smooth parts of an image [4]. High frequencies are transformed with short functions (low scale) and low frequencies are transformed with long functions (high scale).

Important properties of wavelet functions in image compression applications are: compact support (lead to efficient implementation), symmetry (useful in avoiding dephasing in image processing), orthogonality (allow fast algorithm), regularity and degree of smoothness (related to filter order and filter length) [4].

2.2 SPIHT algorithm

The compression method, Set Partitioning In Hierarchical Trees, introduced by A.Said and W.A.Pearlman, represents the beginning of a new generation of wavelet coders and provide a better quality reconstructed images [6]. Some of the best results both in PSNR and visual quality in wavelet coefficients encoding have been achieved when this scheme is applied. Rao and Yip [7] mention SPIHT as probably the most widely used wavelet based algorithm for image compression, providing a standard of comparison for subsequent algorithms.

SPIHT algorithm adopts a tree portioning that maintains three lists of coordinates of components in the decomposition. These are (i) List of Insignificant Pixels (LIP), (ii) List of Insignificant Sets (LIS) and (iii) List of Significant Pixels (LSP). The LIP contains coordinates of components that are insignificant at the current threshold. The LSP contains the coordinates of components that are significant at the same threshold. The LIS contains coordinates of the roots of the spatial parent-children trees. During the encoding process these lists are examined. A list becomes labeled as significant if any of its coefficients has a magnitude larger than a given threshold. Like EZW, the significance map encoding is followed by a refinement pass, in which the representation of the significant coefficients is refined. Also, like EZW, SPIHT coding can be considered as embedded coding that allows progressive transmission [8].

2.3 Huffman coding

Huffman coding is lossless, and is also often used in lossy compression as the final step after decomposition and quantization of an image [9]. Huffman coding creates variable length codes, each represented by an integer number of bits. Symbols with higher probabilities get shorter code words. Huffman coding is the best coding scheme possible when code words are restricted to integer length and it is not too complicated to implement [10]. It is therefore the entropy coding scheme of choice in many applications.

2.4 HWCS

The hybrid wavelet based compression system (HWCS) is based on the assumption that viewers are more interested in the Subject Of Interest (SOI) for a given image than the background [2]. The algorithm works in the following way.

- Select a SOI from the original image and crop it.
- Fill the area left in the original image with the average of the background and treat it as the background image.
- Apply average filter of size 4x4, 8x8, 16x16 or 32x32 to the background image depends on the quality of the background image we require and pass it through a Huffman coder.
- Apply any bi-orthogonal wavelet filter to the cropped image.
- Paste the reconstructed cropped image in the regenerated background image in order to form the original image.

This method could prove to be very important for applications such as picture messaging, where excellent picture quality might not be the overriding concern [2].

2.5 Test Images

In this work we have used only grey level images. In order to make the image set homogeneous and suitable for identification purposes we have imposed some constraints.

- The input image size is 192 x 192 pixels with single grey value background.
- The major subject of interest (Head) should face forward, centered and relatively leveled.

The photographs were taken using a digital camera and preprocessed manually using photo editing tools. The test image set consists of twenty eight photographs.

3.0 PROPOSED ALGORITHM

The algorithm for image compression consists of the following steps in general and is represented in Figure 1.

The algorithm consists of the following steps:

1. Standardize the photographs for partitioning images into four regions.
2. Minimize noise from the image by applying median filter.
3. Split images into four regions of importance.
4. (i) Decompose head region using bi-orthogonal filter and code it with SPIHT.
   (ii) Apply averaging filter of size 2x2 with neck region. Decompose averaged region using daubechies filter and code the result using SPIHT.
   (iii) Apply averaging filter of size 4x4 with the shoulder regions.
5. Code the results produced by step 3 using Huffman coder.
6. Perform post processing by applying median filtering.

All regions were reconstructed by performing decoding and taking the inverse transform.

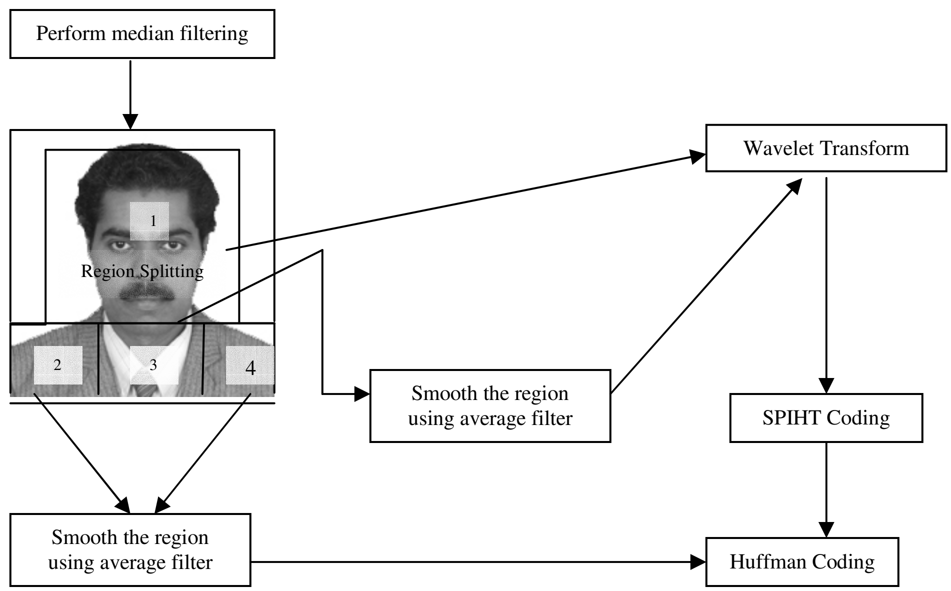

Figure 1. Components of RBHWC

4.0 IMPLEMENTATION

4.1 Region splitting

The images are preprocessed using median filtering. They are divided into four regions: region 1: Most important (Head, Size: 128x128 pixels), region 2: neck (less important, Size: 64x64 pixels), region 3: left shoulder (least important, Size: 64x64 pixels) and region 4: right shoulder (least important, Size: 64x64 pixels). The coordinates were stored for reconstructing the image in the later stage.

4.2 Pre-processing

Region based smoothening is performed with different grades based on the importance of regions in retaining features. The smoothening is not performed in the head region, the neck region is smoothened by using an averaging filter of size 2x2 and the shoulder portions are smoothened using an averaging filter of size 4x4.

4.3 Wavelet transform

It is understood that greater number of decomposition gives better performance of compression, especially for large compression ratios [11]. Taking this into account we have chosen theoretical maximum level of decomposition. The quality of a compressed image depends on filter used for transformation and of the content of an image. For smooth regions smooth filter (Daubechies, coiflet etc.) are appropriate [11]. Daubechies filter is our choice for the neck region. Among a wide range of filters, for different image contents bi-orthogonal filters provide best visual quality [4]. In accordance with that we have selected bi-orthogonal filters for the head region. The other two regions are not decomposed using wavelets but are processed as given in the following section.

4.4 SPIHT and Huffman coding

The wavelet transformed regions are SPIHT coded with different bpp values. The results are fed into Huffman coder. For shoulder regions the averaged matrices are directly passed through the Huffman coder without applying wavelet filter and SPIHT coding.

4.5 Reconstruction and post-processing

Perform all decoding and inverse transform for reconstructing all regions. These regions are then joined using the coordinates stored before. The noise in the reconstructed image may increase as more wavelet coefficients get removed from the image.

The noise is removed by applying a median filter of size 3x3 on the reconstructed image as a part of post processing step.

4.6 Image quality evaluation

We have done objective evaluation based on PSNR value and perception based subjective evaluation by obtaining opinion from several viewers. The grades used for evaluation are 5-imperceptible, 4-perceptible but not annoying, 3-slightly annoying, 2-annoying and 1-very annoying.

5.0 RESULTS

The preprocessing module helps in eliminating salt and pepper noise from the background by applying median filter and to make background with a single grey level value.

A comparison of PSNR values for selected images compressed and reconstructed using HWCS and RBHWC is shown in Table 1. It is found that for all images with different compression parameters our method produces better PSNR value than the HWCS. An average increase of 1.5 in PSNR value is observed.

Figure 2 shows a comparison chart of the PSNR values obtained with the head and neck region compressed with 0.3 bpp.

The average gain in PSNR values (in percentage) for different images compressed with different bpp values are shown in Figure 3. The average gain in the compression of twenty eight images with head and neck coded using bpp 0.1 to 0.4 is shown in the figure 4. It is seen that we achieve better results for all images.

The results of Mean Opinion Score (MOS) from different viewers are given in the Table 2. It is seen that the images coded with 0.2 bpp and above are recognizable. The images coded with 0.4 bpp are perceptible but not annoying, the images with 0.3 bpp are slightly annoying and images with 0.2 bpp are annoying. The reconstructed images produced by our proposed method for different bpp values are shown in figure 5.

	0.1 bpp		0.2 bpp		0.3 bpp		0.4 bpp	
Images	HWCS	RBHWC	HWCS	RBHWC	HWCS	RBHWC	HWCS	RBHWC
Bindu	36.52	37.15	37.42	38.38	37.90	38.98	38.13	39.36
Binija	36.54	37.75	37.19	38.79	37.46	39.27	37.62	39.57
Binu	36.27	37.51	36.72	38.52	36.88	39.01	36.97	39.27
Bishop	38.63	39.18	39.75	40.82	40.49	41.94	40.92	42.47
Deepa	36.89	37.76	37.56	39.24	37.88	40.06	38.07	40.56
Francis	37.69	38.31	38.68	39.79	39.19	40.80	39.45	41.26
Gladston	36.13	36.98	36.76	38.29	37.06	38.96	37.22	39.42
Jobin	36.34	37.31	37.00	38.31	37.23	38.71	37.36	38.95
Justus	36.46	37.50	37.05	38.84	37.33	39.58	37.53	40.13
Jyothsna	37.15	37.89	37.75	39.13	38.00	39.75	38.14	40.06

Table 1. Comparison of PSNR Values of images using HWCS and RBHWC

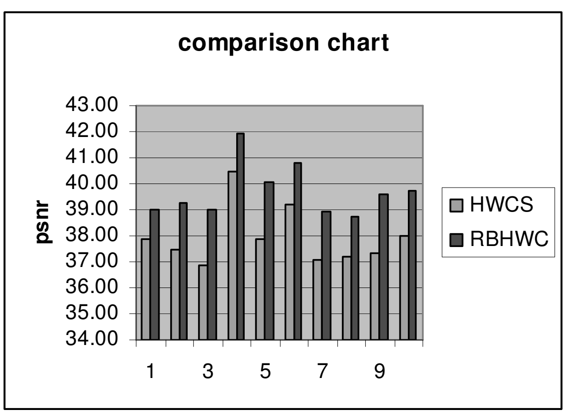

Figure 2. Comarison of HWCS and RBHWC with 0.3 bpp

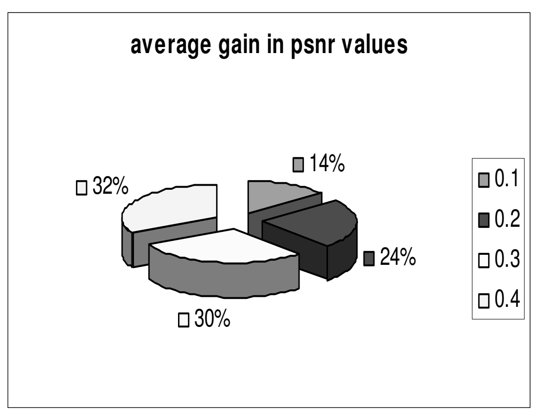

Figure 3. Average gain in psnr values for diff. bpps

Table 2. MOS for diff. Images with diff. bpps

Images	0.1 bpp	0.2 bpp	0.3 bpp	0.4 bpp
Bindu	1	2	3	3
Binija	1	1	3	4
Binu	1	2	2	4
Bishop	1	1	3	4
Deepa	1	3	4	5
Francis	1	2	3	4
Gladston	2	3	3	5
Jobin	1	2	2	4
Justus	1	2	4	5
Jyothsna	1	3	4	5
MOS	1.1	2.1	3.1	4.3

6.0 CONCLUSION

Based on the key idea that facial features are necessary for the proper identification of passport size photographs, we have proposed a new way of implementing hybrid wavelet coding using region splitting. Region splitting selects four regions from the photograph and retains those coordinates for reconstructing the original image. By applying different wavelet filters and coding standards for different region, we could achieve better compression in terms of quality and performance.

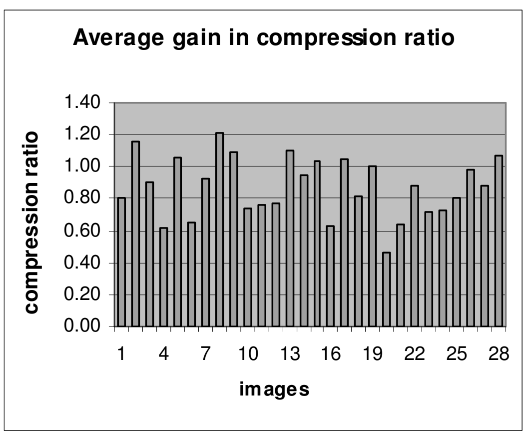

Figure 4. Average gain in compression compression ratio for different images

7.0 References

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(a) (b) (c) (d) (e)

Figure 5. (a) original image (b) reconstructed image with bpp 0.1 (c) with bpp 0.2 (d) with bpp 0.3 (e) with bpp 0.4