A SEGMENTATION CRITERION FOR DIGITAL IMAGE COMPRESSION

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ABSTRACT

This paper is concerned with segmenting light intensity images for the sake of compressing them using lossy compression techniques. Among the most commonly used techniques for image segmentation is Quad-tree partitioning. In this technique, block variance based criteria are usually used to measure the smoothness of the segmented blocks and to consequently classify them. Block variance, however, does not consider the pixel value distribution within the block. Instead of using the block variance as a segmentation and classification measure, we propose using the mean squared deviation from the neighboring pixels mean. The proposed measure is capable of differentiating between blocks not only according to block pixel values but also according to their distribution within the block. This leads to a much better image segmentation and consequently to higher image compression ratios with lower image degradation. The results show the superiority of the proposed measure over the block variance measure.

1. INTRODUCTION

The ultimate goal for any lossy compression system is to put an image in its minimal representation while ensuring that it can be clearly reconstructed with minimal distortion. The level of distortion is measured by the Human Visual System (HVS). The HVS recognizes an image through its regions, not its pixel values. High image compression ratios have been achieved when extracting and encoding this information [1, 2]. One way to achieve high quality compression with high compression ratios is to segment the image into regions having widely differing perceptual importance (the importance of a region corresponds to the amount of information it conveys to the viewer). Regions of each category are then to be encoded using a distinct coding procedure which is suitable for preserving the main visual characteristics of this particular category.

Segmentation is the process of partitioning an image into some non-overlapped regions such that each of these regions is homogeneous while the union of any two adjacent regions is not homogeneous. There are many segmentation techniques in the literature [3, 4, 5, 6]. Segmentation techniques depend on the type of image which being segmented and the application in which this segmented image is to be used.

For its simplicity and minimum overhead as well as efficiency Quad-tree representation [7] has been exploited by many authors in the segmentation phase [8, 9, 10]. Quad-tree is an efficient data structure that requires only a small overhead bit-rate (side information) by restricting the shapes and the number of possible sizes of the final regions to a predetermined set of options. Quad-tree is a top-down segmentation approach. It starts by subdividing initial size blocks into smaller quadrant blocks until a certain smoothness criterion is satisfied or a certain minimum block size is reached (leaf blocks). Each of these leaf blocks can then be classified to one of the various perceptual categories. Block variance based criteria are usually used to measure the smoothness of the segmented blocks and to consequently classify them [8, 9].

Although block variance may be considered as a local statistical measure with respect to the whole image, it is still a global statistical measure with respect to the block itself. Block variance (the mean squared deviation from the block mean) does not consider the pixel value distribution within the block. Figures 1(a)-(c) show three 64x64 image blocks which having equal valued pixels at different locations within each block. Figure 1(d) shows the grey level histogram of any of the

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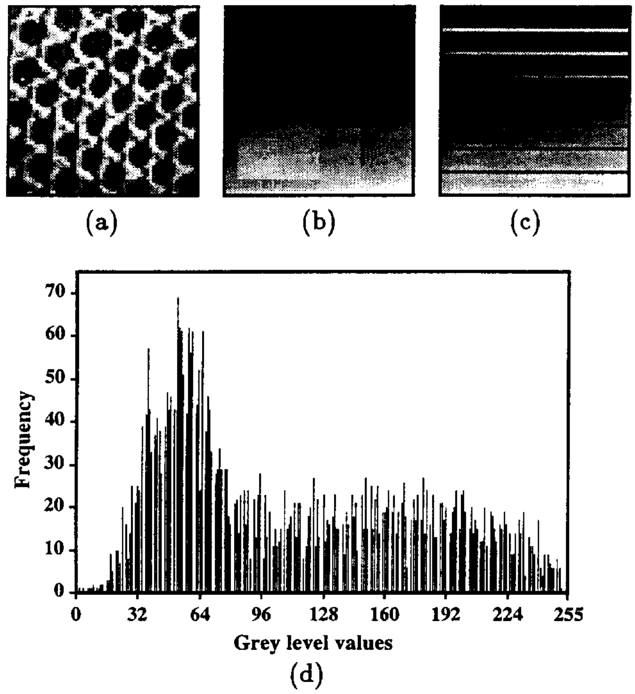

Figure 1: 64x64 image blocks. (a) a texture block, (b) and (c) are a smooth and an edge blocks generated from the block shown in (a) by rearranging the location of its pixel values, (d) the grey level histogram for any of the image blocks shown in (a), (b), or (c).

image blocks shown in Figures 1(a)-(c). The block variance measure is unable to differentiate between these blocks. It gives the same value, 4230.73, for all of them.

2. PROPOSED CRITERION

In this paper, Instead of using the block variance as a segmentation and classification measure, we use the mean squared deviation from the neighboring pixels mean. The proposed measure takes into account the pixel value distribution within the block. It can be calculated by assessing the deviation for each pixel in the block from the mean of its neighboring pixels. For pixel $P(i,j)$ the deviation can be calculated as follows:-

$$P(i,j) - Neighboring\_Mean(i,j)$$

where $Neighboring\_Mean(i,j) =$

$$\frac{P(i+1,j) + P(i-1,j) + P(i,j+1) + P(i,j-1)}{4}$$

The deviation can be considered as a second-order derivative operator (Laplacian operator). The Laplacian operator measures the strength of changes in pixel

Figure 2: Original Lenna image.

values in an image region. The squared deviation values for all block pixels are averaged and used (instead of the block variance) for both the smoothness and the classification criteria. Unlike the block variance measure, the proposed measure can differentiate between the three image blocks shown in Figure 1. The values of the proposed measure for these blocks are 561.11, 0.93, and 513.25 respectively.

3. RESULTS

The validity of the proposed measure is demonstrated by segmenting several images and comparing the results to segmentation based on the block variance measure. As a representative result, consider the Lenna image, shown in Figure 2. Initially, the image is subdivided into 32x32 blocks. Then, the Quad-tree algorithm (as described in [8, 9]) is applied two times (one time based on the proposed measure and the other based on the block variance measure) to segment the image into three different perceptual categories (flat regions, edge regions, and texture regions). Figures 3(a)-(c) show smooth, texture, and edge segmented images which were generated based on the block variance measure, whereas figures 3(d)-(f) show smooth, texture, and edge segmented images which were generated based on the proposed measure. The results show that the proposed segmentation preserves the face details more than the traditional segmentation. This allows us to allocate more bits (while encoding) to those perceptually important regions (i.e. higher fidelity). Also, the texture of the hair is extracted better than the traditional segmentation. Table 1 shows the number of generated blocks after using the traditional and the proposed segmentation techniques. The required number of blocks

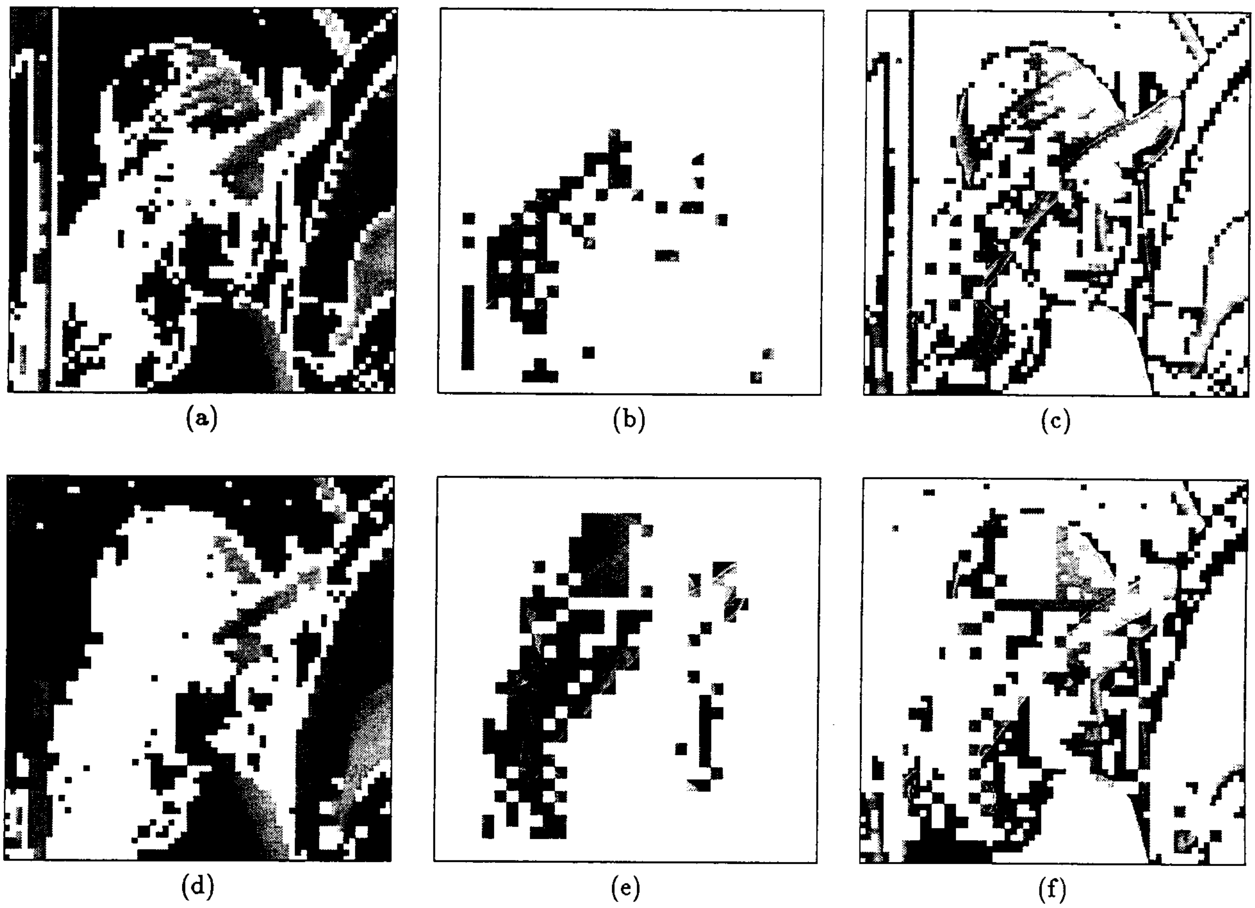

Figure 3: Segmented images. (a), (b), and (c) are smooth, texture, and edge images segmented based on the block variance measure, (d), (e), and (f) are smooth, texture, and edge images segmented based on the proposed measure.

Table 1: Number of generated blocks using the traditional and the proposed segment techniques.

Segmentation method	smooth image	texture image	edge image	total blocks
Traditional	1455	85	1230	2770
Proposed	565	180	1057	1801

in the proposed segmentation technique is less than that in the traditional segmentation technique (i.e. less overhead bits and higher compression ratios). Most of these extra blocks belong to the smooth image segment. This is due to the fact that the block variance is unable to identify smooth blocks easily (blocks have to be divided into smaller sub-blocks first).

4. CONCLUSION

In this paper, the image segmentation problem, using Quad-tree technique, for the sake of compressing images is considered. A new thresholding measure is proposed. The proposed measure is capable of differentiating between blocks not only according to block pixel values but also according to their distribution within the block which leads to a much better image segmentation and consequently to higher image compression ratios with lower image degradation.

5. REFERENCES

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