# IMAGE RINGING ARTIFACT SUPPRESSION IN JPEG2000 USING A POST-PROCESSING ALGORITHM

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## Abstract

In this paper, a new algorithm has been proposed to suppress the ringing artifacts in JPEG2000 images using a post-processing technique. Proposed algorithm operates in two steps. During the first step, edges are extracted using a canny edge detector and these edges are classified into three groups according to their spatial degrees. Finally, variable mean filtering is used to treat the areas which are identified from the edge classification. Simulation results clearly show that the ringing artifacts are reduced significantly with this proposed scheme.

## KEYWORDS

Ringing artifact, Post-processing, Image compression, JPEG2000

## 1. INTRODUCTION

Uncompressed multimedia (graphics, audio and video) data requires considerable storage capacity and transmission bandwidth. Despite rapid progress in mass-storage density, processor speeds, and digital communication system performance, demand for data storage capacity and data-transmission bandwidth continues to outstrip the capabilities of available technologies. The recent growth of data intensive multimedia-based web applications have not only sustained the need for more efficient ways to encode signals and images but have made compression of such signals central to storage and communication technology.

For still image compression, the 'Joint Photographic Experts Group' or JPEG [1,2] standard has been established by ISO (International Standards Organization) and IEC (International Electro-Technical Commission). The performance of these coders generally degrades at low bit-rates mainly because of the underlying

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block-based Discrete Cosine Transform (DCT) scheme [3]. More recently, the wavelet transform has emerged as an innovative technology, within the field of image compression. Wavelet-based coding provides substantial improvements in picture quality at higher compression ratios [4-6]. Over the past few years, a variety of powerful and sophisticated wavelet-based schemes for image compression have been developed and implemented. Because of many advantages, the JPEG2000 codec is used the wavelet-based compression techniques [7].

However, wavelet introduces spurious oscillations in the vicinity of major edges at low bit rates. Such a coding artifact is called as the *ringing artifacts*, which are due to the abrupt truncation of the high frequency wavelet coefficients.

In this paper, we propose a post-processing algorithm, to reduce the image ringing artifacts, based on edge classification and the variable mean filtering technique.

## 2. EDGE DETECTION

Edges are places in the image with strong intensity contrast. Since edges often occur at image locations representing object boundaries, edge detection is extensively used in image segmentation when we want to divide the image into areas corresponding to different objects [8,9].

Since edges consist of mainly high frequencies, we can in theory, detect edges by applying a highpass frequency filter in the Fourier domain or by convolving the image with an appropriate kernel in the spatial domain. In practice, edge detection is performed in the spatial domain, because it is computationally less expensive and often yields better results.

### Canny Edge Detector

The Canny operator was designed to be an optimal edge detector. It takes as input a gray scale image, and produces as output an image showing the positions of tracked intensity discontinuities.

The Canny operator works in a multi-stage process. First of all the image is smoothed by Gaussian convolution. Then a simple 2-D first derivative operator is applied to the smoothed image to highlight regions of the image with high first spatial derivatives. Edges give rise to ridges in the gradient magnitude image. The algorithm then tracks along the top of these ridges and sets to zero all pixels that are not actually on the ridge top so as to give a thin line in the output. The tracking process exhibits hysteresis controlled by two thresholds : $T1$ and $T2$, with $T1 > T2$. Tracking can only begin at a point on a ridge higher than $T1$. Tracking then continues in both directions out from that point until the height of the ridge falls below $T2$. This hysteresis helps to ensure that noisy edges are not broken up into multiple edge fragments.

Usually, the upper tracking threshold can be set quite high and the lower threshold quite low for good results. Setting the lower threshold too high will cause noisy edges to break up. Setting the upper threshold too low increases the number of spurious and undesirable edge fragments appearing in the output.

## 3. MEAN FILTERING

In image processing, filters are mainly used to suppress either the high frequencies in the image, i.e. smoothing the image, or the low frequencies, i.e. enhancing or detecting edges in the image [8,9].

For a square kernel with size $M \times M$, we can calculate the output of the image with the following formula :

$$g(i,j) = \sum_{m=-\frac{M}{2}}^{\frac{M}{2}} \sum_{n=-\frac{M}{2}}^{\frac{M}{2}} h(m,n) f(i-m, j-n) \qquad (1)$$

where $g(i,j)$ represents an output image

$h(m,n)$ repersents a mean filtering kernel

$f(i\text{-}m,j\text{-}n)$ repersents a current image

Mean filtering is a simple, intuitive and easy to implement method of smoothing images, i.e. reducing the amount of intensity variation between one pixel and the next. It is often used to reduce noise in images.

The idea of mean filtering is simply to replace each pixel value in an image with the average value of its neighbors, including itself. This has the effect of eliminating pixel values, which are unrepresentative of their surroundings. Often a 3×3 square kernel is used, as shown in Figure 1.

| | | |
|---|---|---|
| $\frac{1}{9}$ | $\frac{1}{9}$ | $\frac{1}{9}$ |
| $\frac{1}{9}$ | $\frac{1}{9}$ | $\frac{1}{9}$ |
| $\frac{1}{9}$ | $\frac{1}{9}$ | $\frac{1}{9}$ |

***Figure 1.*** *Example of 3×3 kernel mean filtering*

## 4. THE PROPOSED ALGORITHM

### 4.1 The Basic Algorithms

The first step is to extract the edges from the image. Canny operator [8,9] is used in this algorithm to extract the edges from the image. The result from this operator is the edge map but it is insufficient, as edges with different gradients exhibit different spatial degrees of the ringing. The next step is to classify the edge map according to a transition magnitude. The large transition magnitude is classified to the strong edges, the medium transition magnitude is classified to the medium edges and those with small transition magnitudes and contain very fine details of the image are classified as weak edges. After classification the edges, the next step is to post-process the image using the proposed *variable mean filter*.

### 4.2 Variable Mean Filtering

Ringing artifacts are concentrated mostly around regions with high frequency content, i.e., the edges and boundaries of the image. The magnitude and spatial spreading of ringing are functions of the type of edges and the compression ratio. Hence, the proposed algorithm is designed to treat the classified areas by using the variable mean filter which adapts the width of the treatment areas on the basis of the classified edges.

In this algorithm, each type of edge pixel is processed differently. The strong edge is mostly suffered from ringing thus post-processing is performed. The area around the edges become an area of treatment which pixels are smoothed in some broaden region. Medium edge are less suffered from ringing than the strong edge, therefore an area of treatment is also less than an area of treatment of the strong edge. Conversely, the weak edge does not suffer much from ringing and these pixels may also contain fine edges and texture that must be preserved after post-processing. Hence, executions of the pixels are not processed.

The smoothing process is done by taking a weighted average of its neighborhood. The smoothing is performed only on pixels within the area of treatment that has been defined earlier.

The complete flow diagram of the proposed post-processing algorithm is shown in figure 2.

## 5. RESULTS AND DISCUSSIONS

Following parameters have been used for all the simulations.

*Edge detection* : Canny Edge detector

- Strong edge using threshold T1=0.5 and T2=0.2
- Medium edge using threshold T1=0.3 and T2=0.1
- Weak edge using threshold T1=0.25 and T2=0.05

*Area of Treatment* :

- Strong edges = 5 bits around the edges
- Medium edges = 2 bits around the edges

We have applied the proposed algorithm for large number of images and observed that ringing artifacts have been reduced significantly. Figure 3 (a)-(f) shows six different images. Original images are presented in the first column and second and third columns present the JPEG2000 compressed image without the proposed scheme and with the proposed scheme respectively. These images clearly show that the ringing artifacts are effectively suppressed even as the image textures are not degraded and these bring about more pleasing visual quality. We observed the similar improvements with other images as well.

## 6. CONCLUSIONS

We proposed a novel post-processing algorithm to reduce ringing artifacts in JPEG2000 images. The proposed algorithm has been applied to large number of images and results clearly showed that ringing artifacts in the compressed images were reduced significantly. Future work is required to extend this proposed algorithm for wavelet based video codecs.

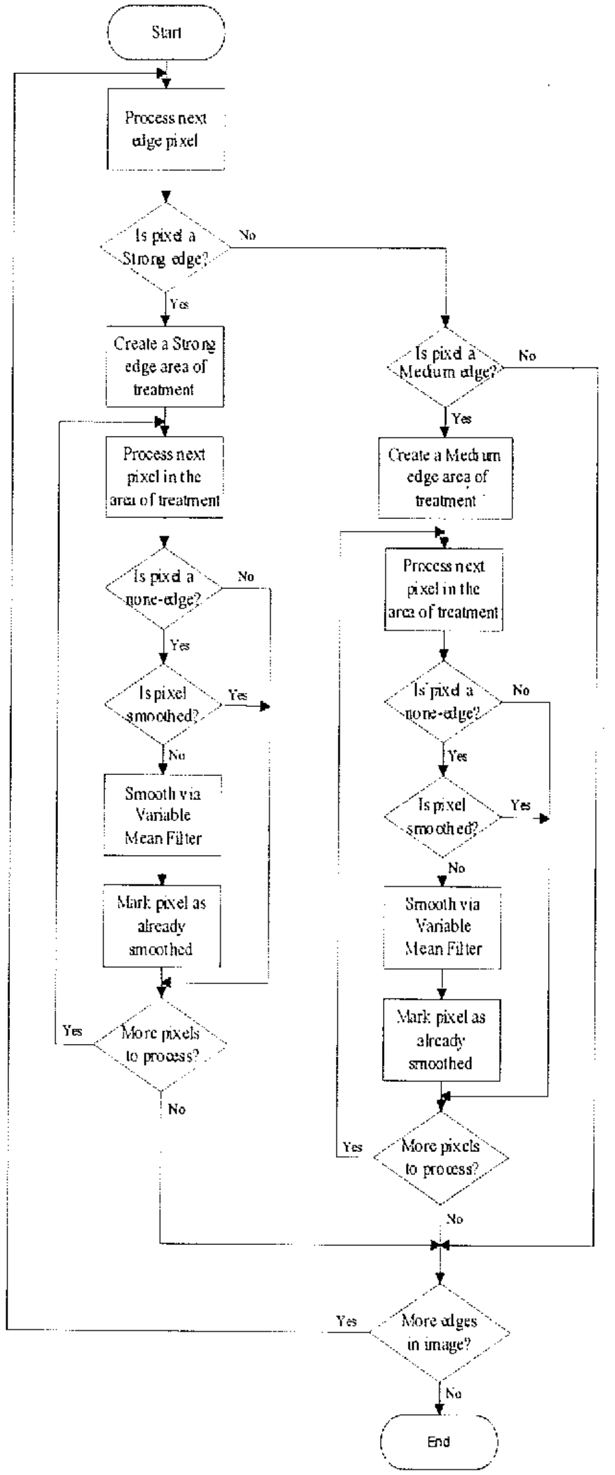


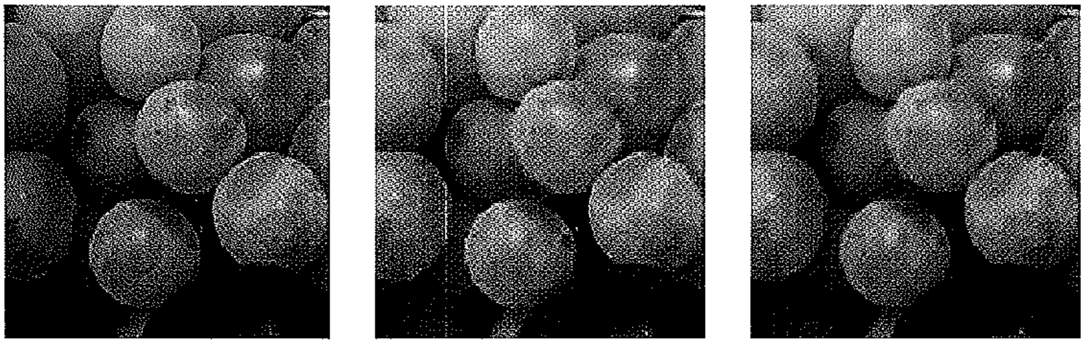

***Figure 2.*** *The flow diagram of the proposed postprocessing algorithm*

**Orignal** **Compressed** **Post-processed**

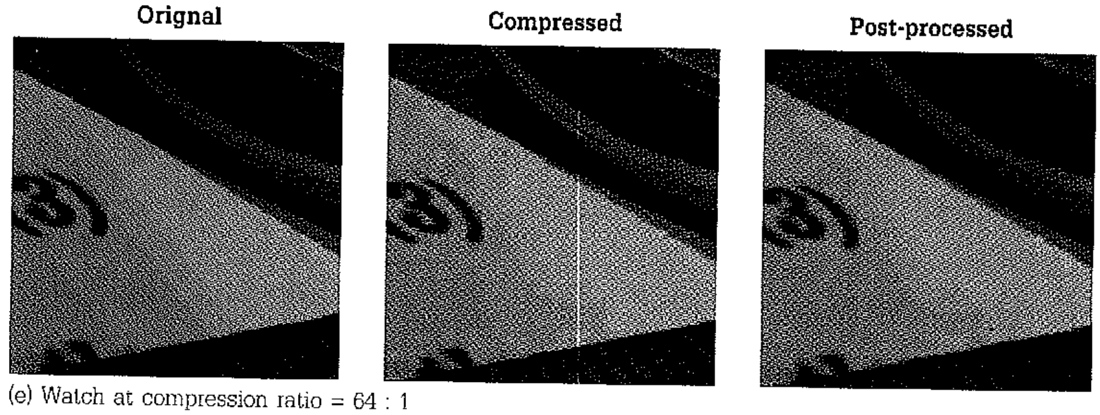
(a) Lena at compression ratio = 64 : 1

(b) Lena at compression ratio = 128 : 1

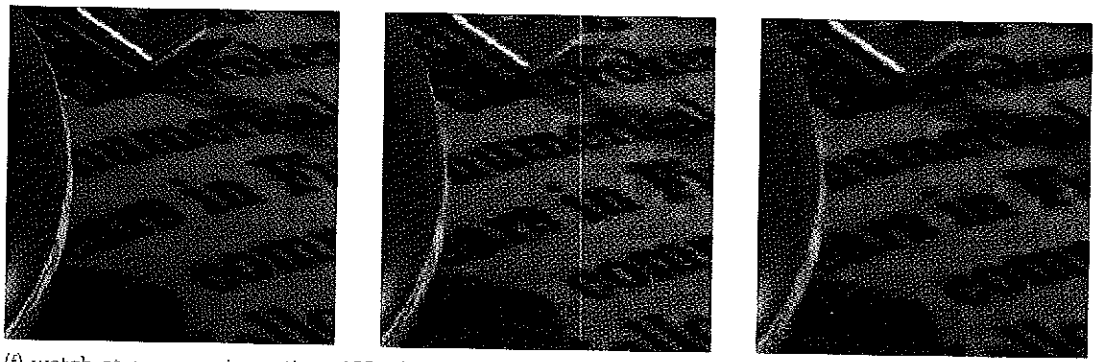
(c) Boat at compression ratio = 64 : 1



(d) Fruits at compression ratio = 64 : 1




(e) Watch at compression ratio = 64 : 1



(f) watch at compression ratio = 128 : 1

***Figure 3.*** *Some reconstructed images before and after applying the proposed algorithm*



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