Performance Analysis of Color Channel for DCT Based Image Watermarking Scheme

Vikas Saxena  
Jaypee Institute of Information Technology University, Noida, India  
vikas.saxena@jiit.ac.in

Aditi Harsulkar  
Jaypee Institute of Information Technology University, Noida, India  
aditi8486@yahoo.co.in

Paridhi Khemka  
Jaypee Institute of Information Technology University, Noida, India  
paridhi.khemka@gmail.com

JP Gupta  
Jaypee Institute of Information Technology University, Noida, India  
jp.gupta@jiit.ac.in

Abstract

Due to improvements in imaging technologies and the ease of digital contents creation and manipulation, today there is a pressing need for the copyright protection of digital contents. It is also essential to have techniques for authentication of the content as well as the owner. This paper examines the suitability of color channel to be used for hiding a monochromatic watermark in a 24 bit colored BMP image. This paper uses the scheme which is based on comparison of middle band DCT coefficients exchange scheme [13]-[14]. This paper also proposes a way to improve the robustness against JPEG attack. Experimental results show that proposed scheme is very robust against JPEG compression along various kinds of image processing attacks.

1. Introduction

In recent years the phenomenal growth of the Internet has highlighted the need for mechanisms to protect ownership of digital media. Exactly identical copies of digital information, be it images, text or audio, can be produced and distributed easily. Therefore to validate the claim of ownership, a proof is required which is provided by the recovery of watermark. A watermark is a form, image or text that is impressed onto paper, which provides evidence of its authenticity. Digital watermarking [3] is an extension of this concept in the digital world. It is a technique that provides a solution to the longstanding problems faced with copyrighting digital data. Digital watermarks are pieces of information added to digital data (audio, video, or still images) that can be detected or extracted later to make an assertion about the data[3,4]. This information can be textual data about the author, its copyright, etc; or it can be an image itself.

There are two domains for digital image watermarking: Spatial Domain and Transform Domain. Spatial domain watermarking is a technique in which the watermark is embedded by directly modifying the pixel values. Least Significant Bit Substitution is a spatial domain technique. The embedding of the watermark is performed choosing a subset of image pixels and substituting the least significant bit of each of the chosen pixels with watermark bits. Extraction of the watermark is performed by extracting the least significant bit of each of the selected image pixels. If the extracted bits match the inserted bits, then the watermark is
detected. This technique is not popular in digital world because it is not robust enough to resist some common attacks.

Transform domain watermarking is a technique in which the watermark is embedded in the transform domain e.g., DCT, DFT, DWT [6]. Watermarking Based on DCT Coefficient Modulation technique[5] embeds the watermark in the DCT domain to increase the robustness of the watermarking scheme against JPEG compression. The watermark bits are embedded in each 8x8 DCT block of the image. It is not wise to embed the watermark bits in the low frequency components of the DCT block, because these coefficients are subject to heavy quantization during JPEG compression [11]. Hence, it is better to embed the watermark in mid or high-frequency DCT components.

2. Preliminaries

Middle-band Coefficient Exchange algorithm [13]-[14]: This technique utilizes the comparison of middle-band DCT coefficients to encode a single bit into a DCT block. FL is used to denote the lowest frequency components of the block; FH is used to denote the higher frequency components while FM is used to denote the middle frequency components. FM is chosen as the embedding region as to provide additional resistance to lossy compression techniques, while avoiding significant modification of the cover image. Two locations $P_k(i_1, j_1)$ and $P_k(i_2, j_2)$ are chosen from the FM region for comparison. We choose the two locations such that they have identical JPEG quantization values as shown in Table 1. Due to this any scaling of one coefficient will scale the other by the same factor preserving their relative size.

<table>
<thead>
<tr>
<th>Table 1. Quantization table</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
</tr>
<tr>
<td>12</td>
</tr>
<tr>
<td>14</td>
</tr>
<tr>
<td>14</td>
</tr>
<tr>
<td>18</td>
</tr>
<tr>
<td>24</td>
</tr>
<tr>
<td>49</td>
</tr>
<tr>
<td>72</td>
</tr>
</tbody>
</table>

We observe that the locations (4, 1) and (3, 2) or (1, 2) and (2, 0) have identical values, therefore we choose them for comparison. The DCT block will encode a “1” if $P_k(i_1, j_1) > P_k(i_2, j_2)$; otherwise it will encode a “0”. The coefficients are then swapped if the relative size of each coefficient does not agree with the bit that is to be encoded.

3. Proposed Scheme

We take four well known 24 bit colored test images of size 512*512 pixels. Test images used are lena.bmp, mandrill.bmp, monarch.bmp and pepper.bmp as shown in Fig (1). The watermark logo used is shown in Fig (2). We embedded the watermark in these images using the middle band coefficient exchange algorithm. To analyze the performance of RGB channels [8], we embedded the watermark separately in R, G and B channels.
After watermark the images in all three color channels, we compress the watermarked images using JPEG compression at various JPEG quality factors. Our results indicate that if watermark is embedded in GREEN channel, recovery is better than other channels. This can be seen in Table 2. The recovered watermarks are shown in Figure 3.

It is clear from Table 2 and Figure 3 that for watermark embedding purpose, Green channel outperforms the Red and Blue color channel.

Now to further improve the quality of extracted watermark logo we are proposing the following steps:

We applied three “preprocessing” steps on the images as follows:

1. Take the 24-bit color image of size 512*512 pixels.
2. Equalize the histogram of Green channel of the image. [1, 2].
3. Embed the watermark in green channel using Middle-band coefficient exchange algorithm [1, 2].

To test our proposed scheme, we equalized the histogram of all three channels (R, G, B) and then watermark the image. Then we performed the following attacks on the watermarked images:

1. **JPEG Attack**: An image is compressed into a stream of bytes and decompressed back into an image. The compression method[12]is usually lossy compression, meaning that some visual quality is lost in the process. After this attack a 769 KB bitmap images is compressed to 27 KB(at low quality: Q=20). This shows that around 95% of data (including the watermark) is lost.

2. **Noise Attack**: Image noise is a random, usually unwanted, fluctuation of pixel values in an image.

3. **Histogram Equalization Attack** [1, 2]: This method usually increases the local contrast of many images, especially when the usable data of the image is represented by close contrast values. Through this adjustment, the intensities can be better distributed on the histogram.
Table-2 shows the results. It is found that if a colored image is HISTOGRAM EQUALIZED before embedding the watermark, recovery of watermark is better i.e. PSNR values are higher. Result also supports our schemes as performance of Green channel is again obvious. Increase in PSNR value of watermarking histogram equalized image is maximized if we equalized green channel.

**Table 2. PSNR of Extracted watermark from JPEG compressed watermark test images**

<table>
<thead>
<tr>
<th>JPEG Compression</th>
<th>LENAE.BMP</th>
<th>PEPPER.BMP</th>
<th>LENAE.BMP</th>
<th>PEPPER.BMP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Q=20</strong></td>
<td>RED (psnr-5.86)</td>
<td>RED (psnr-5.86)</td>
<td>BLUE (psnr-4.45)</td>
<td>BLUE (psnr-4.45)</td>
</tr>
<tr>
<td><strong>Q=40</strong></td>
<td>RED (psnr-5.86)</td>
<td>RED (psnr-5.86)</td>
<td>BLUE (psnr-4.45)</td>
<td>BLUE (psnr-4.45)</td>
</tr>
<tr>
<td><strong>Q=60</strong></td>
<td>RED (psnr-5.86)</td>
<td>RED (psnr-5.86)</td>
<td>BLUE (psnr-4.45)</td>
<td>BLUE (psnr-4.45)</td>
</tr>
<tr>
<td><strong>Q=80</strong></td>
<td>RED (psnr-5.86)</td>
<td>RED (psnr-5.86)</td>
<td>BLUE (psnr-4.45)</td>
<td>BLUE (psnr-4.45)</td>
</tr>
</tbody>
</table>

![Figure 3. Recovered watermarks for lena.bmp after jpeg attack at Q=40.](image-url)

**Table 3. PSNR of extracted watermark from attacked watermarked test images.**

<table>
<thead>
<tr>
<th>Color Channel</th>
<th>LENAE.BMP</th>
<th>PEPPER.BMP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Attack</strong></td>
<td><strong>Jpeg Q20</strong></td>
<td><strong>Hist. Equ.</strong></td>
</tr>
<tr>
<td>RED</td>
<td>original</td>
<td>3.85853</td>
</tr>
<tr>
<td></td>
<td>equalized</td>
<td>4.7334</td>
</tr>
<tr>
<td>GREEN</td>
<td>original</td>
<td>6.2285</td>
</tr>
<tr>
<td>BLUE</td>
<td>original</td>
<td>3.78458</td>
</tr>
<tr>
<td></td>
<td>equalized</td>
<td>4.08999</td>
</tr>
</tbody>
</table>

![Figure 3. Recovered watermarks for lena.bmp after jpeg attack at Q=40.](image-url)

**Table 3. PSNR of extracted watermark from attacked watermarked test images.**

<table>
<thead>
<tr>
<th>Color Channel</th>
<th>MANDRIIL.BMP</th>
<th>MONARCH.BMP</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Attack</strong></td>
<td><strong>Jpeg Q20</strong></td>
<td><strong>Hist. Equ.</strong></td>
</tr>
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<td></td>
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<td>4.08999</td>
</tr>
</tbody>
</table>

![Figure 3. Recovered watermarks for lena.bmp after jpeg attack at Q=40.](image-url)
4. Conclusion

This paper presents a study to analyze the suitability of color channel used to hide the watermark using the classical middle band coefficient exchange scheme for 24 bit color images. This paper also proposes a simple preprocessing for images so that watermarking scheme becomes more robust against JPEG compression and other common image manipulations. Further studies can be conducted to find out the suitability of color channel and preprocessing steps based on watermarking scheme and image characteristics.

5. References


[8] Gael Chareyron and Alain Trémeau, ”Watermarking of Color Images based on spectral modulation of viewing illuminant”, Laboratoire LIGIV EA 3070 - University Jean Monnet Site Carnot - 10, rue Barrouin 42000 Saint-Etienne – FRANCE.


Authors

**Vikas Saxena** is a Ph.D. scholar in Jaypee Institute of Information Technology University, Noida, India. He received ME from VJTI Mumbai in 2001. He has more than 12 research publications in various international journals and reputed conferences. His area of interest is Computer Graphics, Image Processing and Software Engineering.

**Aditi Harsulkar** is a Final year graduate student in the department of Computer Science & Engineering in Jaypee Institute of Information Technology University, Noida, India. Her area of interest includes image processing and digital content security.

**Paridhi Khemka** is a Final year graduate student in the department of Computer Science & Engineering in Jaypee Institute of Information Technology University, Noida, India. Her area of interest includes image processing and digital content security.

**Prof. J.P. Gupta** is the Vice-Chancellor of Jaypee Institute of Information Technology University, Noida, India. Prof. Gupta obtained Master’s Degree in Electronics & Communication Engineering with the Gold Medal in 1973 from the University of Roorkee. He obtained his Doctorate Degree in Computer Engineering from the University of Westminster, London. He has held many coveted teaching and important administrative assignments. He held a position of Professor serving the University of Roorkee (now IIT, Roorkee) for over 25 years.