Enhanced images watermarking based on amplitude modulation

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Introduction

- Color image watermarking

  CPE 2004 embed into

- Amplitude modulation based watermarking
  - Kutter et al. (1998)
  - Puertpan et al. (2001)

Copyright protection (robust against both unintentional and intentional attacks)
Amplitude modulation based watermarking (1/3)

- Watermark embedding process

\[ B' = B + w' \]
\[ B' = 10 + 6 = 16 \]

Original image

CPE 2004
\[ w \in \{1,-1\} \]

<table>
<thead>
<tr>
<th>R</th>
<th>G</th>
<th>B</th>
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<tbody>
<tr>
<td>150</td>
<td>30</td>
<td>16</td>
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Scaling factor
\[ w' = \frac{w s L}{L} \]
\[ s = 0.1, \]
\[ L = 63.6 \quad (150 \times 0.299 + 30 \times 0.587 + 10 \times 0.114) \]
\[ w' = 1 \times 0.1 \times 63.6 = 6.36 \quad \text{round} \quad 6 \]

Luminance
\[ L = 0.299R + 0.587G + 0.114B \]
Amplitude modulation based watermarking (2/3)

- Watermark retrieval process (prediction technique)

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$w'' = B' - B''$

$B'' = \frac{1}{8}(B'_1 + B'_2 + \ldots + B'_8)$

$w'' = 16 - \frac{1}{8} \times 121 = 0.875$

$w = \begin{cases} 
1 & \text{if } w'' \geq 0 \\
-1 & \text{otherwise}
\end{cases}$

$w = 1$
Factors that influence the retrieval performance

\[ B' = B + w' \]

\[ w'' = B' - B'' \]

\[ B'' = \frac{1}{8} (B'_1 + B'_2 + \ldots + B'_8) \]

\[ w'' = B + w' - \frac{1}{8} (B_1 + B_2 + \ldots + B_8) \]

\[ -\frac{1}{8} (w'_1 + w'_2 + \ldots + w'_8) \]
Proposed methods (1/3)

- Balancing watermark bits
  - Assuming that all luminance values of a block are identical

\[
w'' = B + w' - \frac{1}{8} (B_1 + B_2 + \ldots + B_8)
\]

\[
- \frac{1}{8} (w'_1 + w'_2 + \ldots + w'_8) = 0
\]

No. of \( w=1 \) is 4
No. of \( w=-1 \) is 4

\[
w'_1 = w_1 sL_1
\]
\[
w'_2 = w_2 sL_2
\]
\[
\ldots
\]
\[
w'_8 = w_8 sL_8
\]
Proposed methods (2/3)

- Equalizing the luminance values of a block
  - Gaussian pixel weight mask [Puertpan et al. (2001)]

\[
\begin{bmatrix}
70.2 & 68.8 & 66.5 \\
75.3 & 63.6 & 67.6 \\
73.5 & 67.5 & 64 \\
\end{bmatrix}
\]

\[
\begin{bmatrix}
0.019 & 0.100 & 0.019 \\
0.100 & 0.531 & 0.100 \\
0.019 & 0.100 & 0.019 \\
\end{bmatrix}
\]

\[L' = 66.9\]
Proposed methods (3/3)

- Modifying the method of pixel prediction in the retrieval process
  - Pixel value replacing

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Experiment results (1/3)

- 256×256 color testing images

- Watermark and pattern of pseudo-random bit-stream

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CPE 2004
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Experiment results (2/3)

- Being attacked by JPEG compression

![Graph showing the impact of JPEG compression on Average NC over different attack strengths. The graph compares Kutter's, Puertpan's, and the proposed method.](image-url)
Experiment results (3/3)

- Being attacked by 20% image cropping and 45° image rotating

Kutter’s

Puertpan’s

Proposed scheme
Conclusion

- Three improving methods are proposed to enhance Kutter’s and Puertpan’s watermark retrieval performance.
Thanks for your listening...
Comparison at various $s$

- Average PSNRs of watermarked images
  
<table>
<thead>
<tr>
<th>$s$</th>
<th>0.02</th>
<th>0.06</th>
<th>0.1</th>
<th>0.2</th>
<th>0.3</th>
<th>0.4</th>
<th>0.5</th>
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<tbody>
<tr>
<td>Average PSNR (dB)</td>
<td>40.10</td>
<td>30.92</td>
<td>26.58</td>
<td>20.74</td>
<td>17.36</td>
<td>15.01</td>
<td>13.25</td>
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- Average NCs between retrieval watermark and original watermark
Comparison at various $\sigma^2$

- **Average PSNRs of watermarked images**
  
  Average PSNRs at various $\sigma^2$
  
<table>
<thead>
<tr>
<th>$\sigma^2$</th>
<th>0.1</th>
<th>0.2</th>
<th>0.3</th>
<th>0.4</th>
<th>0.5</th>
<th>0.6</th>
<th>0.7</th>
<th>0.8</th>
<th>0.9</th>
<th>1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average PSNR (dB)</td>
<td>16.25</td>
<td>19.85</td>
<td>20.51</td>
<td>20.75</td>
<td>21.00</td>
<td>21.31</td>
<td>21.66</td>
<td>22.04</td>
<td>22.44</td>
<td>22.83</td>
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- **Average NCs between retrieval watermark and original watermark**

![Graph showing Average NCs]