Blind MPEG-2 Video Watermarking Robust Against Geometric Attacks: A Set of Approaches in DCT Domain

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Introduction

- Focus on typical geometric processing for bit-rate reduction, **row cropping**, arbitrary-ratio downscaling, and frame dropping.

- Both the embedding and the extraction of watermarks are done in the **compressed domain**, so the computational cost is low.

- These are commonly suggested methods:
  - (1) Synchronization
  - (2) Autocorrelation
  - (3) Invariant watermarks

- In one word, **none of above techniques mentioned is suitable and practical for watermarking compressed video.**
Outline

- Watermarking robust against cropping
- Watermarking robust against downscaling
- Watermarking robust against Frame dropping
- Experimental results
- Conclusion
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Watermarking robust against cropping

- Cropping?
- Only **removes part of the rows** in each frame of the video, assuming hereinafter the cropping is only done horizontally.
- Main idea:

  Embed the same watermark bit in every row within a column with width = 8.
Compressed video → Partially decode

Partition each 8x8 block in 2-D DCT domain into eight 1x8 blocks 1-D DCT

Embed AC₁ by even/odd rule

Quantize by Q_step

C₁', C₂',……….,C₇'

C₁, C₂,……….,C₇

One watermark embedding unit

Eight 1-D block DCT

2-D block DCT coefficients of Y of I frame.

Watermarking robust against cropping
Watermarking robust against cropping

- **even/odd rule:**
  - If the hidden bit is “1”, AC1 is set to be an odd number by $-1$ or doing nothing.
  - If the hidden bit is “0”, AC1 is set to be an even number by $+1$ or doing nothing.
- Why we choose reverse algorithm to change the parity (even/odd) of AC1 is because we want to avoid too great a change of bit rate.
Watermarking robust against cropping

- Q_step?
  - The bigger the Q_step, the higher the **flipping threshold**, and the lower the watermark **extraction error**, but, in return, the greater the **distortion** caused by the embedded watermark, and vice versa.

- Total embedded bits?
  - **N/8 bits** (N is the frame width).

![Diagram showing watermark embedding process](image)
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Watermarking robust against downscaling

- Downscaling?
- Downscaling will totally change the bit stream of MPEG-2 video.
- Main idea:
  - As we know, the spatial downscaling of one frame has roughly equivalent effect to the truncation of high-frequency band in its **full DCT domain**.
  - Embed watermarks in its low-frequency band.
Watermarking robust against downscaling

Compressed video

Partially decode

Set $AC_i \geq AC_i' + \Delta$ to embed bit "1"
Set $AC_i \leq AC_i' - \Delta$ to embed bit "0"
Watermarking robust against downscaling

- How to choose $N_w$?
  - The more bits embedded in each group, certainly the less the imperceptibility.

- How to choose $\Delta$?
  - decision threshold.
  - tradeoff between watermark imperceptibility and robustness.

- In our experiments, $\Delta$ is chosen as $10\% \times |AC_i|$. 
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Watermarking robust against Frame dropping

- Main idea:
  - Cropping and Frame dropping.
  - Downscaling and Frame dropping.

how to partition the MPEG-2 video into scenes?
- P frame: intrablocks / interblocks.
- B frame: forward predicted blocks / backward predicted blocks.
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Experimental results

- Cropping
  - Host video “Susie on the phone” (CIF size 288*352) : 375 frame, Totally (352/8)*375 = 16500 bits are hidden.
- Attack: cropping processing is accompanied by a pair of lossy decoding–encoding.
Experimental results

- **Downscaling**
  - Host video: *tempete, flower, calendar, football, susie, and tennis*. (encode the watermark bits by using turbo code with code rate 1/3, iterations = 5).
  - 10 bits ($N_w = 10$) are hidden in each of selected frames of video.
Experimental results

Besides, the technique also demonstrates extreme robustness against *small-angle rotation*, *uniform numerical processing*.

<table>
<thead>
<tr>
<th>Types</th>
<th>Description</th>
<th>Average error rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotation</td>
<td>anticlockwise angle = 0.22°</td>
<td>0.04</td>
</tr>
<tr>
<td>Rotation</td>
<td>anticlockwise angle = 1.23°</td>
<td>2.01</td>
</tr>
<tr>
<td>Rotation</td>
<td>clockwise angle = 1.54°</td>
<td>2.13</td>
</tr>
<tr>
<td>Further bit rate reduction</td>
<td>From 6Mbps to 4Mbps</td>
<td>0.00</td>
</tr>
<tr>
<td>Format conversion</td>
<td>From MPEG2 to AVI, and reverse</td>
<td>0.00</td>
</tr>
</tbody>
</table>
Conclusion

- Focus typical unintentional geometric processing widely used to decrease the bit rate of MPEG-2 video.
- Blind watermarking techniques.
- Watermark embedding and extraction are done directly in the compressed domain.
- The proposed techniques can be adopted to watermark other DCT-based homogeneous compressed videos.