On the Subjective Effect of StirMark When Applied to Videos

Toshiyuki Yokohaa, Tadashi Matsumotoa, Shigeyuki Sakazawab, Liang Zhaoa and Hideo Yamamotoa

aDepartment of Information Science, Faculty of Engineering, Utsunomiya University,
Yoto 7-1-2, Utsunomiya-shi, 321-8585, Japan
E-mail: yoko@degas.is.utsunomiya-u.ac.jp

2Visual Communications Laboratory, KDDI R&D Laboratories, Inc.,
O-hara 2-1-15, Kamifukuoka-shi, 356-8502, Japan
E-mail: sakazawa@kddilabs.jp

Abstract: StirMark is a generic tool for robustness testing of image watermarking algorithms. This paper considers the subjective effects of StirMark when it is applied to videos. We observe that most attack functions provided by StirMark can be classified according to the shape distortion due to different locations. Subjective tests are performed to show our observation.

1. Introduction

Recently, digital watermark are widely used for still images, videos and others. In developing a watermarking algorithm, it is important to evaluate its robustness. For that purpose, a well-known testing tool for still image oriented watermarking schemes is StirMark (see [1,2]). On the other hand, however, there is no good generic testing tool known for video oriented watermarking schemes. Thus StirMark is also widely used to evaluate video oriented schemes, by treating a video clip as a set of still pictures.

Unfortunately, since the original target of StirMark is still image, one may meet unexpected odd things when applying its attacks to videos, which consequently restrict the usage of StirMark. In this paper, we consider the subjective effects of StirMark when it is applied to videos. The aim of this study is to provide StirMark users a useful reference on its applicable domain, hence can give a better understanding on the video oriented watermarking.

As reported in a previous study [3], we observe that the geometric distortion attack could produce an unexpected distortion, i.e., a still straight line could be looked as if it performs a wave-like motion if one did not choose the attack parameter carefully. In this paper, we try to give a detailed evaluation on the attack functions provided by StirMark. We will first classify the attacks according to the shape distortion due to different locations. Then we will show several subjective tests to verify this classification.

The rest of this paper is organized as follows. An introduction of StirMark is described in Section 2. Attack classification and subjective tests are shown in Sections 3 and 4, respectively. Finally we conclude in Section 5.

2. Attacks of StirMark and the Problem

The first version of StirMark was published in November 1997 as a generic watermark test tool. After several version-ups and rewritings, now it (version 4.0) offers about 30 kinds of attack functions such as the JPEG compression, image transforms and various geometric distortions.

When considering the subjective effects, we observe that all attacks are performed by changing some or all pixel data. This can result a shape distortion for an object in the picture. For a single still image, the shape distortion may be not recognized by a human eye (hence StirMark is said a good testing tool for still image oriented watermarking schemes).

However, for a video clip, if the shape of the same object changes in two successive pictures, then it is easy for an observer to find the difference and recognize it as a distortion. Therefore it can be said that, in order for an attack not being recognized by the observer, it must not change the shape of an object (may be moving) in different ways for successive pictures, or due to different locations in pictures. In other words, the distortion of the attack depends on how much an object is changed in successive pictures.

Let us see an example in Figure 1. The original picture is the left (a). We apply a distortion attack of StirMark which shifts the pixel data according to a 2D sine wave function. The periods of the wave function are half of the width and half of the height of the original picture, respectively. The picture after the attack is shown in Figure 1 (b).

(a) before attack
Figure. 1 Distortion attack.

(b) after attack

Compare the lattice before and after the attack. It is clear that a square that was straight before is distorted in different directions according to the locations (see cycles in Figure 1 (b)). In this case, we can see only a single picture which may not look so strange. But when we consider a video clip which contains a moving square, the above attack will result a distortion for a moving object. Hence an observer may recognize it as an odd sharp transformation of the object. As a result, he or she may consider the above attack of StirMark results unpleasant effect.

In the next section, we will consider the attack functions provided by StirMark in this aspect in details.
3. Attack Classification

We have discussed the reason of why an attack may result unexpected and odd effects in the previous section. In this section, based on the previous observation (shape distortion due to location or picture), we classify the attack functions provided by StirMark. Mainly they can be classified in the next three categories.

a. High distortion:
   An attack that can result a sharp distortion for at least one pixel due to different locations.

b. Low distortion:
   An attack that results a sharp distortion for less than one pixel due to different locations.

c. No distortion:
   An attack that results no change except for the computational error.

For test, we used the next video clip. There are two objects in the picture: a grid of size 21x21 pixel and a solid square of size 11x11 pixel. At first, they move from the top-left corner straightly to the top-right corner, one pixel per picture. Then they move from the top-right corner straightly to the down-right corner (one pixel per picture), then from the down-right corner straightly to the top-left corner (one pixel per picture). Some pictures after attacks are shown in Figure. 2 to Figure. 8. Let us see them in the following.

3.1. High distortion attacks

These are attacks that change the shape of an object for at least one pixel if its location changes.

(a) Distortion attack
   This is the default attack of StirMark 3.1, which moves pixel data with specified distortion. See Figure. 2. It is clear that this attack can distort the shape of an object due to different locations.

(b) JPEG compression attack
   It is the attack that reproduces the JPEG compression. The resulted picture is shown in Figure. 3 with attack parameter 50%. Actually this attack does change the shape of an object directly. It is the noise that distort the picture quality, which can be observed in the figure. Moreover, the (random) noise varies with pictures, hence we classify it in this class. Notice that, since the distortion is due to quantization, the noise level depends on the value of the parameter.

(c) Remove Line attack
   This is the attack that removes all pixels of a column or row in the specified frequency, where removed pixels are interpolated from neighbors. The parameter used in our test is 5, i.e., every five pixels is removed, see Figure. 4.

   In the first frame, all the vertical lines of the lattice disappeared, and the square is cut too. In the second and the tenth frames, some lines are removed actually. But since they are interpolated from the adjacent pixels, we cannot see the difference.

   ![Frame](image)
   Figure. 2. Distortion attack.

   ![Frame](image)
   Figure. 3. JPEG compression attack.

   ![Frame](image)
   Figure. 4. Remove line attack.

3.2. Low distortion attacks

These are attacks that change the shape of an object for less than one pixel.

(a) Rotation attack
   It is the attack that rotates the picture around the center of the picture. The resulted picture is shown in Figure. 5. Gradation can be observed for the objects. Actually the distortion is little in the first and in the second frames, but is obvious in the tenth frame. This could result a shape distortion for a moving object, where the distortion can be adjusted by the rotation angle.

(b) Scaling attack
   It is the attack that enlarges or reduces a picture. The resulted picture with 75% reduction is shown in Figure. 6. No significant distortion is found by this attack. Of course the distortion depends on the ratio of enlargement or reduce.
3.2. No distortion attack

These are attacks that result no distortion due to different locations (except for computational error).

(a) Cropping attack
This is the attack that cuts off a part from the picture. The resulted picture is shown in Figure. 7, where 5% of the edge side are removed. Clearly the obtained pictures have no distortion (due to different locations).

(b) Median filter attack
This is the attack that replaces a pixel data by the median value of its “neighbor” pixels. The parameter is 2, i.e., the median is computed from pixels that is 2 pixel far from the target pixel data. See Figure. 8.

Although the shape of an object may distort much, the distortion does not depend on a special frame.

4. Subjective Effect Test for Natural Videos

4.1. Subjective Tests
In Section 3, we have considered the subjective effects of StirMark when applying its attacks on an artificial video. In this section, we perform tests with natural videos.

For comparison, we use three video clips. One is the same as used in the previous section (Figure. 9 (a)), which contains a moving lattice and a moving square. The second is “akiyo” (Figure. 9 (b)), which is a common news video with low motion. The third is “mobile” (Figure. 9 (c)) which has a high motion (a moving train, a moving calendar and the background also moves). We choose four attacks: JPEG compression attack form the “High distortion” class; Rotation attack from the “Low distortion” class; and Median Filter attack and Cropping attack from the “No distortion” class, respectively.

For each video, we applied 16 attacks (4 levels for each attack). Thus there are in total 48 videos. Ten observers are shown the original video at the first. Then they are asked to evaluate the 16 video clips after applying the attacks. The evaluation score baseline is shown in Figure. 10, in which we use the following evaluations.

a. Sharp – Not sharp
   The average sharpness of the clip.
b. Smooth – Not smooth
   The average smoothness of the clip.
c. Natural – Unnatural
   The average evaluation on if the clip is natural.

Letting the original clip be scored 5, there are 5 levels on the quality of the shown video clips.

![Figure 9. The tested videos.](image)

![Figure 10. Evaluation score baseline.](image)

4.2. Test result

The evaluation score is obtained by the average value of the ten individual scores. The result is shown from Figure. 11 to Figure. 14.
From the figures, we can see that, for the JPEG compression attack, both two natural videos get evaluation scores similar to “geometric object”. This matches our above observation. On the other hand, for the Rotation attack, natural videos get a fairly higher score than “geometric object”. We consider that this is because that slight distortion in a natural picture is not easy to recognize by human eyes. Finally, for Median filter and Cropping, since there is no significant distortion in the picture’s quality, the scores almost have no change.

Furthermore, we can see that the scores for “geometric object” and “mobile” perform similarly according to the change of attack level. This shows that “mobile” is a kind of video in which shape distortion is easy to be recognized by human eyes. The reason is that “mobile” contains a lot of squares and circles, whose sharp distortion is sensitive to a human’s eye.

Though not tested, we consider that other attacks perform similarly to the above tests.

5. Conclusion

In this paper, we have considered the subjective effects of StirMark when it is applied to video clips. Major attack functions provided by StirMark are classified according to the shape distortion due to different locations. The classification is summarized in Table 1.

Table 1. Classification of the StirMark’s attacks.

<table>
<thead>
<tr>
<th>High distortion attack</th>
<th>Low distortion attack</th>
<th>No distortion attack</th>
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<tbody>
<tr>
<td>Distortion</td>
<td>Rotation</td>
<td>Median Filter</td>
</tr>
<tr>
<td>JPEG</td>
<td>Rescale</td>
<td>Cropping</td>
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<tr>
<td>Remove Line</td>
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From experimental tests, we observe that subjective effects matches the above observation. Therefore we can conclude that a StirMark user should lower the level of high distortion attack in order to hide the subjective effect.

As the future work, the applicable domain of each StirMark’s attack and other attacks that are not considered in this paper require further studies.

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References