EVALUATION OF WATERMARKING PARAMETERS EFFECT ON WATERMARKED VIDEO QUALITY)

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ABSTRACT

This paper is focused on the final video quality evaluation in digital watermarking systems. First, the two basic evaluation methods of the resulting watermarked video data – the subjective and objective methods are compared. Next, the effect of the watermarking parameters on the final video quality and artefacts visibility are tested in practice and the results are shown. The Peak Signal Noise Ratio (PSNR) calculation and the word expression evaluation of each final watermarked video are introduced in tables and graphs.

1. INTRODUCTION

There are various methods used for copyright protection of digital data. Embedding a watermark into digital data – watermarking is a relatively reliable and nowadays often used method. The aim of this technology is to guarantee the authenticity of the digital data and the copyright at the same time. Digital watermark technology is defined as an embedding of redundant information – the watermark – into multimedia data in such a way that it is imperceptible to human senses [1].

The performance analysis of a watermarking algorithm is not an easy task. There are some tools for analyzing the watermarks (StirMark, CheckMark [2]), but they test the watermark robustness rather than the perceptual quality of resulting video data containing a watermark [2]. There is no general procedure defined for the evaluation of watermarked data quality. In practice there are two basic types of evaluation – subjective and objective [3].

2. EVALUATION OF THE WATERMARKED VIDEO QUALITY

The aim of watermarking systems is to embed watermarks that cannot be perceived by human senses. Invisibility along with robustness and security belong to the three basic watermark requirements that are closely connected. Sufficient watermark imperceptibility is at the expense of its robustness and security, and vice versa. Therefore the watermark always means a compromise between these three requirements [1, 2, 4]. It follows from the above that a very robust watermark will cause visible changes in the original data.

2.1. Subjective Evaluation

The subjective evaluation is based on the rate of people ability to distinguish the resulting changes in multimedia data. The problem of this evaluation method is that the human sensibility is various and thus the result can be different for different persons. On the other hand, the advantages are in the simplicity and no need for any mathematical operations [3].

2.2. Objective Evaluation

The objective evaluation method overcomes the disadvantages of subjective quality evaluation. This method is based on mathematical calculations. In the objective evaluation of watermarked video, the quality standards are used. Theese standards result from parameters used for the evaluation of static image quality. There are three very frequently used standards – Mean Absolute Error (MAE), Mean Squared Error (MSE) and Peak Signal to Noise Ratio (PSNR) [3]. The related mathematical formulas are available in [5].

3. EVALUATION OF THE WATERMARKED VIDEO QUALITY USING THE WATERMARK 2.0 APPLICATION

Based on the watermarking algorithm presented in [5] an application called Watermark 2.0 was developed. This application provides Discrete Cosine Transform (DCT)-based watermark embedding and detection in the frequency domain.

The quality evaluation of the resulting watermarked video in Watermark 2.0 application is provided by both the objective and subjective method. To be able to make an objective evaluation, the PSNR value of the watermarked video is always computed and displayed after watermark embedding. A great advantage of this application is the wide range of watermark parameter settings, which enables extensive testing and comparison of the effects of individual watermarking parameters on the quality of the resultant watermarked video.

For every resulting watermarked video sequence the PSNR value is computed. Besides, the objective evaluation of every watermarked video the watermark visibility test is also performed. For the objective evaluation, both the word expression and the Mean Opinion Score (MOS) scale are used. The MOS scale is defined by ITU-T recommendation P.800 and indicates numerically the perceived quality of the tested media. The MOS was originally used for the telephone transmission quality evaluation but now it can be used for different purposes. It is expressed as a single number in the range from 1 to 5, where 1 = Bad, 2 = Poor, 3 = Fair, 4 = Good and 5 = Excelent quality [6]. The resulting MOS and word expression evaluation were determined as the avarage of five people's opinions. The word expression of artefacts visibility is mentioned because the PSNR value sometimes does not take into acount apperance of block artefacts in the watermarked video. The well-known video sequences "Snowboard" and "Singer" has been used for the tests. The resolution of the video sequence "Snowboard" was 640x480 pixels and the resolution of the "Singer" video was 320x240 pixels. The static black-and-white image was used as a watermark.

3.1. Effect of the DCT Coefficient Position on the Final Video Quality

First, the effect of DCT coefficients position on the resulting video quality and the watermark perceptibility was tested. In sequence, the low-, middle- and high-frequency coefficients were used for watermark embedding. All the other watermark parameters were constant during the tests. Table 1 shows that the most significant changes and the worst video quality were caused by modifications in the low-frequency coefficients. In contrast, changes in the high-frequency coefficients were visible the least.

Video Sequence	Frequency Domain	Objective Evaluation	Subjective Evaluation	
		PSNR [dB]	Artefacts Visibility	MOS
Snowboard	Low	52.15	Light	3
Snowboard	Middle	55.43	Slight	4
Snowboard	High	61.61	No	5
Singer	Low	50.35	Big	2
Singer	Middle	54.49	Light	3
Singer	High	59.36	Slight	4

Table 1: Effect of the position of DCT coefficients on the PSNR value and the resulting video quality. Number of blocks=32, Robustness=20, Image component=luminance (Y).

3.2. Effect of the Number of Blocks on the Final Video Quality

The next parameter that was tested was the number of blocks, which were used for the watermark embedding. Table 2 and Figure 1 show that the effect of the number of blocks on the resulting video quality is not so significant. The reason is that only in the case of very large number of blocks is the watermark visible. At the same time, it was discovered that the PSNR value does not match exactly the objective quality of the resulting video. The tests performed showed that large number of modified blocks causes rapid decrease of the PSNR value but the effect on visual video quality is not so significant.

Video Sequence	Blocks Number	Objective Evaluation	Subjective Evaluation	
		PSNR [dB]	Artefacts Visibility	MOS
Snowboard	8	60.08	No	5
Snowboard	64	50.50	No	5
Snowboard	128	48.0	No	5
Snowboard	512	42.26	Slight	4
Snowboard	1024	39.81	Light	4

Table 2: Effect of the number of blocks on the PSNR value and the resulting video quality. Robustness=20, Image component=luminance (Y), Frequency domain=middle.

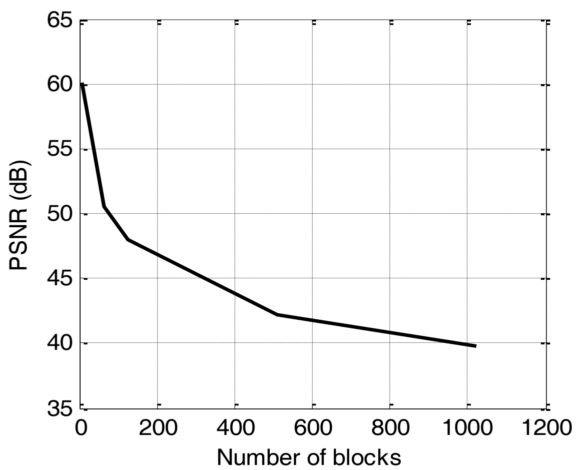

Figure 1: Effect of the number of blocks on the PSNR value of the resulting video.

3.3. Effect of Watermark Robustness on Final Video Quality

Other significant parameter, whose influence has been tested, is the watermark robustness. The results of these tests can be seen in the Table 3. It is evident that for the method used the watermark is imperceptible up to the robustness of 50. For larger values slight changes became perceptible in the resulting video.

Video Sequence	Robustness	Objective Evaluation	Subjective Evaluation	
		PSNR [dB]	Artefacts Visibility	MOS
Snowboard	10	59.49	No	5
Snowboard	30	55.90	No	5
Snowboard	50	53.75	No	5
Snowboard	70	52.17	Slight	4
Snowboard	100	51.23	Slight	4

Table 3: Effect of the watermark robustness on the PSNR value and the resulting video quality. Number of blocks=32, Image component=luminance (Y), Frequency domain=middle.

3.4. Effect of Image Components on the Final Video Quality

The last parameter tested during the evaluation was represented by the image components used for the watermark embedding. That is to say that in the used watermarking algorithm every video frame is divided into one luminance component Y and two chromatic components Cb and Cr. Therefore the effect of the image components on the PSNR value and the watermark perceptibility has been tested. The results of the tests show that the image component selection has almost no influence on the PSNR value or on the resulting video quality. The watermark was always imperceptible and the PSNR values changed slightly.

However, close relation between the watermark visibility and the structure of the video sequence itself was discovered. From the subjective viewpoint, watermark perceptibility depends also on the position of the artefacts generated by watermark embedding. If the artefact is positioned in a more textured part of image, then this artefact is almost invisible. By contrast, if the artefact is positioned in a homogenous image area, the distortion is more visible. This shows that the subjective evaluation of watermarked video depends on the video structure, i.e. whether the video is largely composed of active or monotone scenes.

3.5. Determination of the Effect of Watermarking Parameters on Final Video Quality

Based on the results mentioned above can be concluded that the position of the DCT coefficients has the greatest influence on the watermark perceptibility and the resulting video quality from all watermarking parameters. On the contrary, the most significant effect on the PSNR value is caused by the number of blocks, from which the DCT coefficients are selected. Subjective evaluation has revealed that the DCT-based watermarking method applied brings various artefacts into the resulting video. The visibility ratio of these artefacts is dependent on the watermarking parameters and, in particular, on the original video characteristics especially on the video scene structure.

Figure 2 shows the effect of the position of frequency coefficients on the watermark visibility. The figure on the left shows the example of the original video frame and the figure on the right shows video frame with watermark, which was embedded into the low-frequency coefficients. The difference between both frames is perceptible at first sight. The watermark embedded into the low-frequency coefficients caused visible artefacts in watermarked frames.

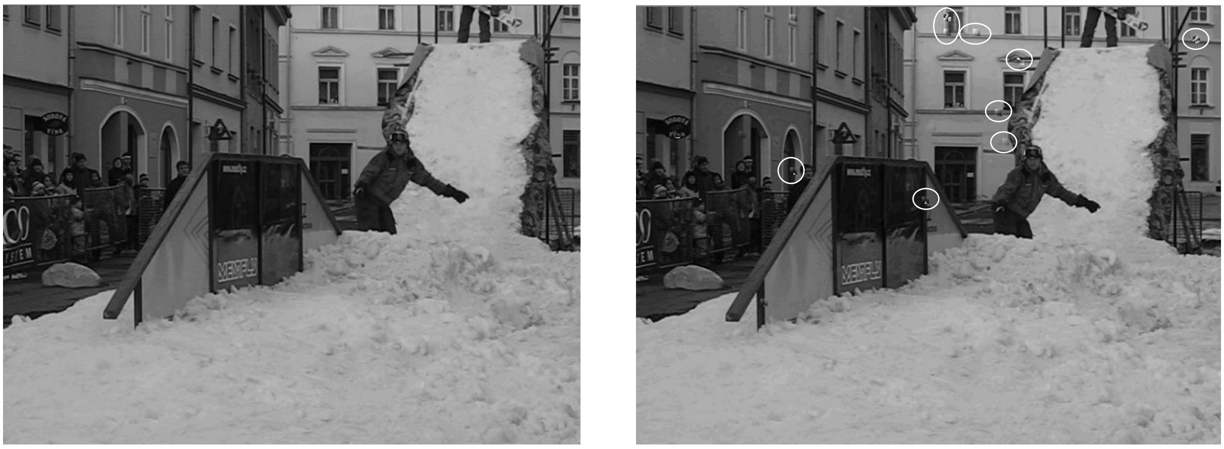

Figure 2: Effect of the position of DCT coefficients – original frame (on the left), watermarked frame with watermark embedded into low-frequency coefficients (on the right).

4. CONCLUSION

In this paper, the effect of several watermarking parameters on the final watermarked video quality has been investigated. For this purpose an application was developed, which enables watermark embedding and detection in frequency domain and provides wide range of parameter settings for the watermarking process. This feature enables a detailed test of the influence of parameter values on the resulting video quality. The evaluation was carried out both objectively and subjectively. Based on the results we can conclude that the higher the watermark robustness is or the larger the modified part of the frame is, the changes in the image are more visible and more significant final video quality degradation is caused.

REFERENCES

[1] Seitz, J.: Digital Watermarking for Digital Media. Hershey, Information Science Publishing, 2005.

[2] Hartung, F., Kutter, M.: Multimedia watermarking techniques. Proc. of the IEEE, Vol. 87, 1999, pp. 1079-1107.

[3] Winkler, S., Gelasca, E. D., Ebrahimi, T.: Toward perceptual metrics for video watermark evaluation. Applications of Digital Image Processing, Vol. 5203, 2003, pp. 371-378.

[4] Barni, M., Bartolini, F.: Watermarking Systems Engineering. New York, Marcel Dekker, 2004.

[5] Hosek, J.: Watermarking of Video Content. Brno [Diploma Thesis], Brno University of Technology – Faculty of Electrical Engineering and Communication - Department of Telecommunications, 2007.

[6] ITU-T Recommendation, Telephone Transmission Quality: Methods for Objective and Subjective Assessment of Quality. Recommendation P.800, 1996.