Abstract—To improve the picture quality on high-end display systems, coding artifact reduction is an important function in the video processing chain. We investigate the use of a masking algorithm to reduce the visibility of coding artifacts that typically result from lossy, block-based compression methods.

I. INTRODUCTION

The full digitization of the video chain from acquisition to display has shifted the focus from analogue video noise reduction, such as film grain and transmission noise, to coding artifact reduction.

For efficient transmission and/or storage of digital video data, block DCT-based compression methods, such as MPEG-2 and MPEG-4 [1] are commonly used. As these compression methods are lossy, artifacts become visible after decoding. These artifacts include blocking artifacts, ringing, blurring, and mosquito noise [3].

In the high-end consumer market flat screen displays systems, such as PDP-TVs and LCD-TVs show a trend of increasing display sizes, display resolution and contrast ratios. Although these aspects improve the picture performance, they can have a negative influence on the perceived quality of video sources impaired by coding artifacts. Furthermore, since such display systems typically do not have access to the encoding parameters of the bitstreams, which are required for optimal suppression of coding artifacts, they rely on post-processing methods to improve the perceived quality of artifact impaired video [3].

In this paper, we investigate the use of a masking technique [4] as a post-processing algorithm for digital artifact reduction designed for high-end display systems. In section II, the concept of digital artifact reduction is briefly described, Section III discusses the proposed algorithm and Section IV presents results.

II. CODING ARTIFACTS

Coding artifacts are the result of removing information from the original video data. Typically, e.g. by MPEG-coders, information is reduced by quantizing coefficients in the DCT domain. Depending on the type of DCT coefficients that are quantized, this results in different artifacts. The most noticeable are blocking artifacts resulting from quantization of the low-frequency DCT coefficients, ringing, resulting from quantizing high frequency DCT coefficients, and mosquito noise, appearing whenever identical picture information in succeeding frames is encoded differently.

A large number of coding artifact reduction algorithms have been developed [2] to improve the perceived picture quality. Often, such algorithms include processing steps to distinguish artifacts from video data, to measure and/or estimate the visibility of the artifacts, and to reduce the artifacts by means of filtering.

To distinguish artifacts from video information without access to the coding parameters, one has to rely on knowledge of the principles of the coding scheme. Applying low-pass filtering, tuned to the coding artifacts, commonly performs the actual reduction of coding artifacts.

Although low-pass filtering of artifacts has been shown to improve the overall picture quality [3], it causes a blurred result, especially on high-end flat screen displays. In the next section, the use of masking instead of filtering is proposed as an alternative suitable for high-end displays to reduce the visibility of some of the coding artifacts listed above.

III. PROPOSED METHOD

Consider a video signal $F(x,n)$ originating from a “clean” video signal $V(x,n)$ polluted with coding artifacts, where $x$ indicates a 2D position and $n$ a frame number. Assume the coding artifacts can be considered as an additive signal that is a function, $C$, of $V(x,n)$ and the coding parameters $Q$ as indicated in (1). For post-processing algorithms this function and the parameters $Q$ are unknown.

$$F(x,n) = V(x,n) + C(V(x,n);Q).$$

In general, the spatial frequency characteristics of $V(x,n)$ and $C(V(x,n),Q)$ are not equal, suggesting that a third signal $S(F(x,n))$ can be added to $F(x,n)$ that masks $C(V(x,n),Q)$ more than $V(x,n)$. This results in the video signal $F'(x,n)$, as shown in (2):

$$F'(x,n) = V(x,n) + C(V(x,n);Q) + S(F(x,n)).$$

Fig. 1 illustrates this by comparing a single image of a video signal before and after applying MPEG compression.

![Fig. 1. The left image shows a frame of the Akiyo sequence. The right image shows this image after MPEG-compression.](image-url)
frequency spectra of both images. Fig. 3 illustrates the 2D difference spectrum, i.e. the normalized spectrum of the compressed image minus the spectrum of the original image of a single frame from the Akiyo sequence. Fig. 2 and Fig. 3 shows that coding artifacts manifest themselves mainly as high spatial frequencies.

Fig. 2. Horizontal (left) and vertical (right) projections of the normalized spatial frequency spectrum of the Akiyo image. The dotted line indicates the spectrum of the original image, the solid line indicates the spectrum of the compressed image.

Fig. 3. The difference in normalized spatial spectra before and after compression.

To reduce the visibility of these artifacts, we apply a noise shaping technique similar to noise diffusion [4]. A dithering technique shapes high spatial frequencies, such that the artifacts are reduced when weighted with the spatial contrast sensitivity function [5] of the human visual system.

Fig. 4 depicts the scheme of our proposed method.

Fig. 4. Diffusion scheme of the proposed method.

A masking signal $E(x,n)$ is added to $F(x,n)$, while a filtered version of $E(x,n)$ is recursively subtracted. $E(x,n)$ is obtained in a three step process from $F(x,n)$, as illustrated in Fig. 5.

First, we roughly separate between the low and high frequencies with a high-pass filter on $F(x,n)$. The high-pass filter is designed to pass mainly the high frequency artifacts.

Fig. 5. Construction of $E(x,n)$.

Next, the signal is non-linearly distorted using:

$$D(x,n) = \begin{cases} 
1: H(x,n) > 0 \\
0 : H(x,n) = 0 \\
1 : H(x,n) < 0 
\end{cases}$$

This generates a binary distributed signal containing harmonics. Finally, the amplitude of the signal is amplified with a gain $A$, which is controlled by a coding artifact estimator that measures the position and visibility of blocking and ringing artifacts.

IV. RESULTS AND CONCLUSIONS

A close up of the MPEG-coded image of Fig. 1 is shown in Fig. 6 together with the output image resulting from the processing.

Fig. 6. Close up of the result.

Fig. 6 shows that block artifacts and ringing are masked by a high frequent signal that reduces the visibility of the artifacts. This shows that masking is an alternative to low-pass filtering for reducing coding artifacts.

REFERENCES