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EXPERIMENTAL STUDY OF VIDEO SIGNAL MASKING METHOD FROM LEAKAGE ON TECHNICAL CHANNELS

EGOR ADAMOVSKY, VLADIMIR ZHELEZNYAK
Polotsk State University, Belarus

A new way of masking a video signal from leakage through technical channels with adaptive video noise frames has been experimentally investigated. The article represents the results of masking proposed test video frame with dynamic white noise and adaptive masking frames, where the video frame reconstruction was realized by synchronous accumulation of video frames. Experimental studies have confirmed the advantages of a new method of masking a static video frame with adaptive video noise frames.

Introduction. Video display modules are the source of electromagnetic emissions, which can be intercepted and restored, forming a data leakage channel in this way. This signal emission corresponds to the image displayed on the screen, generated by the computer's video card [1]. The static video image on the monitor screen can be received periodically with the frame update period f_k.

The restoration of a video signal in this case is possible, if accurate timing parameters are known for allocating video frames and their successful synchronous accumulation. If we use additive addition with dynamic noise as the signal accumulates, its amplitude grows linearly, depending on the number of accumulated frames, and the noise accumulates according to the root-mean-square law [2].Thus, the improvement in the signal-to-noise ratio (SNR) will be proportional $\sqrt{n}$.

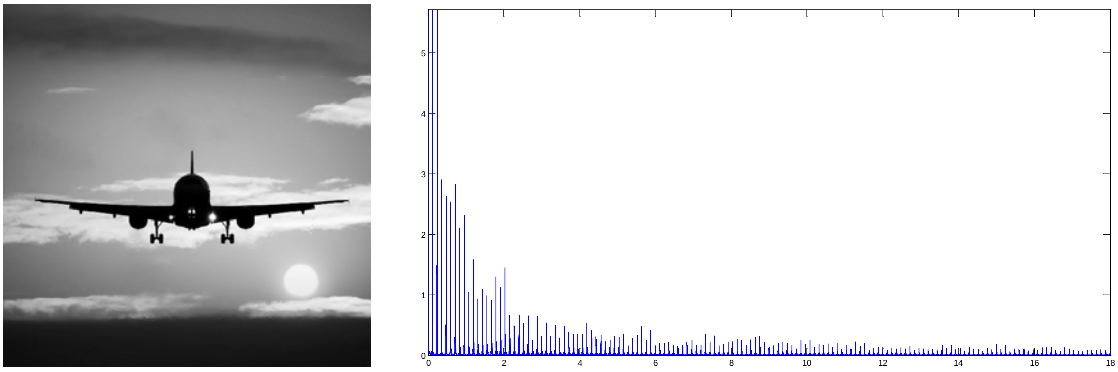
Justification of the method of masking video information. In carried out studies [3], the effectiveness of masking a video signal by a chaotic impulse sequence (CIS) is substantiated. It is demonstrated that for the most complete destruction of information, the masking signal must have a certain shape of the spectrum. Its structure needs to have more energy in the low-frequency range, and lower – in the high-frequency range. This is a consequence of the typical form of the video signal spectrum, in which the energy of the spectral components falls with increasing frequency, and they themselves concentrate near the harmonics multiples of the line frequency of the video image. CIS has a spectrum of a similar shape that allows it to mask video information much more efficiently than white noise.

Images of real objects contain large-scale and small-scale components, which in the frequency representation of the correspondence between low- frequency and high-frequency region. As the test frame for this experiment, the image of the aircraft was selected (Fig. 1). The clear contrasting contour of the aircraft against the background of uniform sky is well recognized as a large-scale structure. Details of the aircraft, such as chassis, lighting, engines and fairings of the mechanism for closing closed shows are small-scale information.

Fig. 1. The airplane image as a test frame

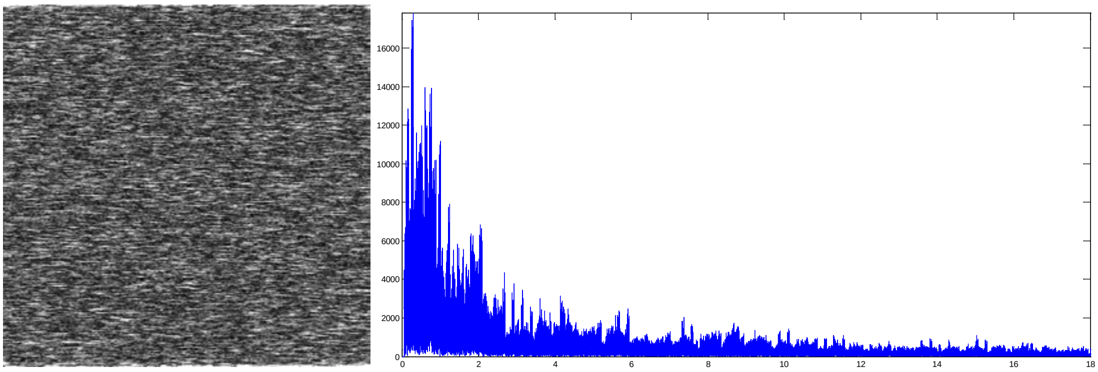
Existing white noise generators, such as «Гном-3» [4] and others, are able to mask only the high-frequency range satisfactorily, and also do not take into account such features of the video signal as synchronism based on the principle of measuring sync pulses and uneven distribution of the amplitudes of the spectral components.

The proposed method takes into account these features of the video signal, and offers more efficient distribution of the spectral masking signal components due to its formation based on the masked video frame itself. Realization of this method consists of obtaining the spectrum of masked video signal in a digital form and constructing, on the basis of its line harmonics of the envelope. This envelope modulates uniform noise, which after this operation acquires a characteristic shape. Thus, with extra addition of the original and masking signal, most of the spectral components are suppressed by noise (Fig. 2–3).



a) *b)*

Fig. 2. Test video frame and its spectrum: a) original image; b) spectrum of the image



a) *b)*

Fig. 3. Masking video frame and its spectrum: a) resulting masking image;
b) spectral representation of masking image

Experimental investigation of video masking. Experimental study of the proposed method of masking a video image demonstrates its effectiveness with respect to white noise and CIS. The evaluation of increasing video signal security consists of masking it with a dynamically changing masking frame, dynamic white noise, and generated synchronous masking frames.

The experiment results on synchronous accumulation of a camouflaged test video frame with a video signal duration of 30 seconds are presented in SNR = 1/15 (Figure 4), with SNR:

$$SNR = \left(\frac{A_{signal}}{A_{noise}} \right)^2 \quad (1)$$

where A_{signal} – RMS signal amplitude;

A_{noise} – RMS noise amplitudes.

a) b) c)

Fig. 4. Reconstructed synchronous accumulation of test video frame (video signal duration 30 s):
a) noisy with dynamic white noise; b) noisy with dynamic masking frame;
c) noisy with synchronous adaptive video noise frames

As a result, the conducted experiment confirmed the efficiency of masking video frames in the proposed way with respect to white noise with the same SNR of noisy video signal.

In figure 4a, it is easy to distinguish the airplane contour and all the above-mentioned small-component components. In addition, it is possible to distinguish the background details, such as the shape of clouds and the sun, without clear contours. In Figure 4b, a large-scale object can still be identified, but small details are already difficult to distinguish. In Figure 4c, the image is completely destroyed.

Figure 5 shows the change dependence in the security of masked video frames with duration of up to 750 frames, which corresponds to 30 seconds of video at the rate of 25 frames per second, synchronous accumulation during masking with dynamic white noise and dynamic adaptive video noise frames.

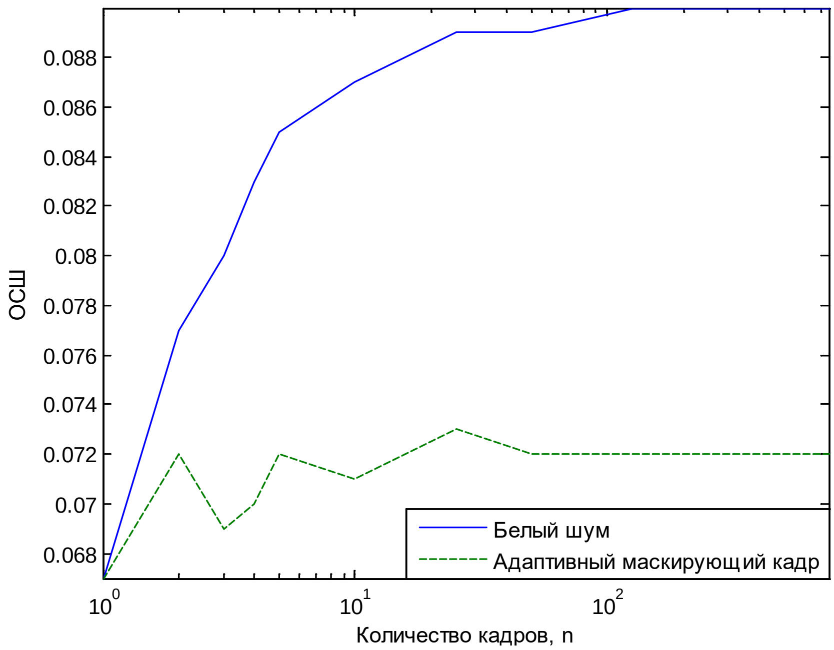


Fig. 5. Dependence of the SNR of the camouflaged video image
on the number of frames in synchronous accumulation

Figure 5 demonstrates that the proposed masking method does not significantly improve the SNR of the masked signal in synchronous accumulation (dotted line in Figure 5) compared to the white noise masking method (solid line in Figure 5).

Conclusion. Experimental studies have demonstrated the advantages of the proposed method of adaptive masking of video information for static and dynamic video frames. Masking the test video frame with adaptive video noise frames during synchronous accumulation of video frames provides the best quality of masking and does not allow significant improvement of SNR compared to dynamic masking frame and dynamic white noise.

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