# Application of Nonlinear Stochastic Differential Systems for Data Protection in Audio Files

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*Abstract* – **Application of audio files data protection is presented, which is based upon the use of the nonlinear stochastic differential systems (SDS). Model of SDS and its implementation results are presented, which prove efficiency of this method.**

*Keywords* – **audio, data protection, nonlinear stochastic differential system.**

## I. INTRODUCTION

Data protection in audio files is one of current problems in information security field. This problem is usually solved with cryptographic methods in computer systems, but new solutions are still being searched for. Usage of nonlinear stochastic differential systems is one of such new methods [1, 2].

## II. THEORY AND PRACTICAL APPLICATION

The essence of the approach is following: audio signal is entered as a parameter of nonlinear SDS and the corresponding output signal of the SDS is used instead of the audio signal, and that protects the latter.

The proposed approach [2] is considered for nonlinear SDS, which behavior is described by the following SDE:

$$\ddot{x} + b_1\dot{x} + b_2|\dot{x}|\dot{x} + c_1 x + c_3(t)\,x^3 = n(t), \qquad (1)$$

where $n(t)$ – white noise with intensity $N_0$, $c_3(t)$ – parameter, by means of which audio signal is entered.

If $x_1 = x(t)$ and $x_2 = \dot{x}(t)$ and that system of equations is reduced to first order, following equations are acquired by Euler method from Eq. (1):

$$\begin{aligned} x_{1_{i+1}} &= x_{1_i} + x_{2_i}\Delta t; \\ x_{2_{i+1}} &= x_{2_i} + \zeta_i\sqrt{N_0\Delta t} - \\ &-\left(b_1 x_{2i} + b_2|x_{2i}|x_{2i} + c_1 x_{1i} + c_{3i}x_{1i}^3\right)\Delta t. \end{aligned} \qquad (2)$$

Here $\zeta_i$ – the i-th value of normally distributed random variable with zero expectation and variance 1.

Based on Eq. (2), $x_1$ values are calculated upon the ordinates of the audio signal entered by means of coefficient $c_3$ and are written to the audio file instead of the corresponding ordinates of the original audio signal.

The original audio signal is restored in reverse order. By $x_1$ values from Eq. (2), $c_3$ values are calculated – the ordinates of the original audio signal:

$$\begin{aligned} c_{3i} = \Big\{&2x_{1i+1} - x_{1i} - x_{1i+2} + \zeta_i\sqrt{N_0\Delta t^3} - c_1 x_{1i}\Delta t^2 - \\ &- b_1\left(x_{1i+1} - x_{1i}\right)\Delta t - b_2\left|x_{1i+1} - x_{1i}\right|\left(x_{1i+1} - x_{1i}\right)\Big\}\Big/\left(x_{1i}^3\Delta t^2\right). \end{aligned} \qquad (3)$$

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Two computer programs were created on the basis of Eqs. (2) and (3) for data protection in audio files. First program protects original audio file: ordinates of audio signal are replaced with $x_1$ values according to Eq. (2). Second program restores audio signal according to Eq. (3).

Example of original audio signal is on Fig. 1.

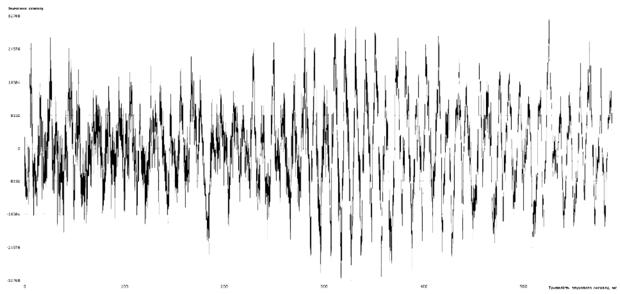

Fig.1 Original audio signal

Example of audio signal protected with developed programs can be seen on Fig. 2.

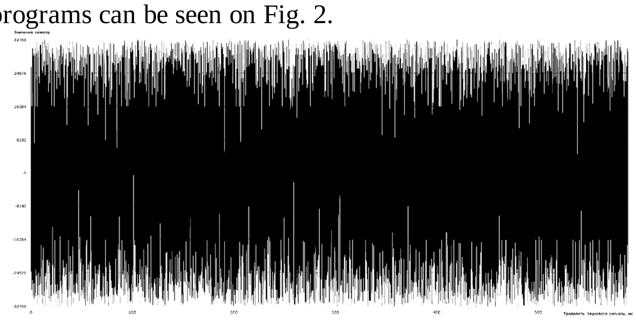

Fig.2 Protected audio signal

Restored audio signal is almost identical to the one on Fig. 1.

Both sound and speech signals were tested with these programs and can be processed equally well.

## III. CONCLUSION

Computer programs developed for data protection in audio files based upon the use of the nonlinear stochastic differential systems prove efficiency of this method for any audio signal: both sound and speech.

## REFERENCES

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[2] S.B. Prykhodko, “Usage of nonlinear stochastic differential systems for protection of speech signals.