Summarizing of the Informational Tutorial Materials on Digital Processing and Noise-Immune Coding of Audio- and Videosignals

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***Abstract* — In this abstract is given the summarizing of the informational tutorial materials for digital processing and noise-immune coding of audio and video signal, developed by the leading scientists of scientific academic laboratories and higher Ukrainian institutions taking into consideration their own works as well works of the leading research and technology companies and developed countries.**

***Key words* — information flows, tutorial materials, digital processing, noise-immune coding, audio signals, video signals, filtration, digitization.**

I. INRODUCTION

The methods of digital processing of signals are used wider and wider today. They gradually replace analog processing based methods of audio and video signals processing, which is now the most used.

The use of reliable information transmission is also popular. This led to the development of the codes that control errors and error finding mechanisms. However, such codes can be also employed in informatics, audio and video technology and other fields.

For this reason the subjects connected with studying of the basis of Digital Signal Processing − DSP theory and algorithm and noise-immune coding of audio and video signals began to appear in the syllabus of higher technical institutions.

Ministry of Science of Ukraine, a team of authors from *National Technical University of Ukraine and State University of Telecommunications* wrote textbooks [1-3] on the summarizing and studying of the DSP and noise-immune coding of audio and video signals theory and practice.

First of all, in the tutorial materials the information about the advantages of digital processing and noise-immune coding of audio and video signals comparing to the analog one is proved.

The advantage of the DSP of analog signals is shown when using discrete quantities. Moreover, this discontinuity is displayed in two ways - during temporal discretization and during amplitude quantization of signals. This complicity can be explained by the fact that today computers are used for signal processing, so the typical for analog signal processing problem of instability is solved. Another advantage is the relatively low price of the DSP, which constantly decreases even for the most complex types of DSP. This allows producing efficient systems with moderate expenses.

II. THE MAIN PART

As the number of fields in which DSP can be applied increases, the questions of the similarities and differences in the use of its basic methods and equipment in various technical fields become important. The differences can be partially explained by the initial preconditions and limitations such as the speed of data transmission, working in real time requirement etc., that are not equal. However, sometimes the differences occurred simply because of the insufficient information transmissions among the technical fields, so the acquaintance with the DSP methods used in one field determined the progress in other.

The reasons for the employing DSP in different technical fields are versatile. In some field, for example radiolocation, hydrolocation, seismology, the use of DSP is determined by the generality and high accuracy of this method. In other cases, for instance during audio and video signals processing, the expected long-term cost benefit is an essential factor.

DSP solves two main tasks – the transformation of the methods of data submission in a signal and the reducing of information content. Through the transforming of method of data submission the extracting of data from the signal can be simplified; the reducing of information content is the deleting of the unnecessary information.

The work [1] summarizes the theoretical basis of the digital processing of audio and video signals and consists of three main chapters, which comprehensibly give the basic theory needed for the understanding of DSP of analog information.

First, the basic concepts and characteristics of the signal are considered – classification and graphical representation, noises and interferences; types, dimensions, mathematical description, models; signal type transformation and spectral representation.

The problem definition of DSP is based on the understanding and studying such theoretical basics as Fourier transform; generalized functions and discrete signal recovery; relationship between continuous and discrete Fourier transform; Nyquist-Shannon theorem; concepts of linear invariant systems.

The understanding of digital signal filtering is based on the studying of such issues as digital filters; Z-transform; FIR filters; quadrature mirror filter.

Equally important is the ability to understand and practically apply the following theoretical positions – wavelet transform; fast algorithms of discrete Fourier transform; convolution of sequences and its calculation; the use of windows; autocorrelation and its calculation; Hartley transform; discrete cosine transform; Hadamard-Walsh transform; Gray code; Haar transform.

During the studying of the theory of digital images processing particularly important is understanding and practical application of such processes: discretization and restoration of continuous, deterministic and random images; signals in real systems discretization; the influence of the shape pulse rate.

Understanding of the quality of the digital processing related to the theoretical issues of the effects associated with overlapping spectra; interpolation functions in real systems, image reconstruction; image processing-element transformations; linear and zonal contrast images; solarization of an image; conversion histograms equalization; the use of spreadsheet-element method for converting images; optimal linear, mask and median filtering of images.

Equally important is the study of the understanding of issues related to the transport digital information systems, namely elements and channels of data transfer; mathematical models of data transfer channels, including digital transfer analog signals; differential pulse-code modulation, adaptive PCM and DPCM, delta modulation and sigma-delta modulation; coding with dividing into strips.

Generalization of the tutorial informational materials on noise-immune coding information is given in the textbooks [2, 3].

The textbooks present the evidence that the reliable transmission of information through the channels led to the development of codes that control errors. However, these codes have many other applications such as computer science, digital audio and video etc. As most data channels as well as data processing equipment are unreliable, the error finding mechanisms are becoming important. The guarantee for high reliability of data transmission is the use of codes that control errors. If the error is detected, the problem associated with it can be solved by making the retransfer of data.

Noise-immune coding is used to detect and / or correct errors that may occur in a discrete signal during its transfer through channels. In the capacity of a basic code that is subjected to noise-immune coding, the primary binary code of constant length is used.

The errors are more difficult to correct than to detect or prevent. The procedure of the faults corrections involves two combined processes: correction of the error and determining its place (message identification and position in the message). On solving these two problems (trivial fix), you must invert the fault bit value. In the terrestrial channels, where the probability of error is small, the method of error detection and retransfer of the fragment containing the faulty code is usually used. In case of error detection the receiver that does not know which bits are fault, just rejects this fault block and asks for the retransfer of it. This scheme is effective because it requires the smallest amount of redundant information.

For the satellite communication channels with the typical substantial signal delays in the transfer channels, constraints in mass and volume of equipment, substantive noise pollution of the channel, the systems of forward error correction are attractive. Such systems are the most effective. The main point of the transfer of additional information is the transfer of it along with the useful information that allows the receiver not only to detect errors but also to fix them. It uses a number of known noise-immune codes, which are classified according to various criteria.

The work [2] examines the relationship between the theory and practice of noise-immune coding. The Galois field arithmetic theory of linear block codes and the theory of cyclic codes, practical procedures of not only detecting errors, but also determining their location occupy the main position in the work. The basic principles of noise-immune coding and building correcting Hamming, Bouza-Hokvinhema-Chowdhury and others codes are given. The emphasis is put on the decoders and decoding algorithms.

A significant number of the codes given above complicate it for the engineering staff to select the most suitable codes for solving technical problem concerning noise-immune coding of the information.

The information materials of the sections [2] of the transfer of digital information and coding; errors occurring and detection; interdigital distance and the ability to correct errors; finite fields and calculations according to the module; polynomial coefficients from GF (2) and computational schemes; cyclic code and its codecs; Hamming and Bouza-Chowdhury, Hokvinhema corrective codes; linear codes; code control and correction; packet error correction; decoding of BCH code that corrects single, double and triple errors; method of splitting into groups the complete set of integers and the method of constructing the standard configuration for the linear code; partition and groups; standard configuration for the linear code; representation of the linear code in the form of the cyclic code; generative polynomial, generative matrix and parity check matrix; scheme for the division of generative polynomial and parity check matrix will help to solve the problem of choosing the suitable codes.

The methods of producing and also practical schemes for the cyclic codes decoding using different decoding principles discussed in [3]. The methods of coding and decoding non-binary cyclic Reed-Solomon codes and basic principles of the encoder and decoder realization enabling to detect and correct errors in data blocks and also the Berlekamp–Massey algorithm for the key equation solution. The methods for the correction of errors and erasures are given.

III. CONCLUSIONS

The described generalized informational tutorial materials on digital processing and noise-immune coding of audio and video signals will help teachers and professionals to expand and use the theoretical and practical knowledge more effective and students to get the necessary information on the theory of

multimedia signals focusing on the development of intuition and informed judgment in this area. The mathematical formalism, of course, is essential and is based on the intuitive understanding of the processes and not vice versa.

The described tutorial materials not only contain questions and examples that illustrate the fundamental principles of signal processing, but are also supplemented with the new developments to raise interest, especially among students and graduate, of the prospects of research in this area.

REFERENCES

[1] Digital processing of audio and video multimedia systems / P. F. Oleksenko, V. V. Smith, B.C. Lazebny, G. M. Rozorinov, A. A. Osprey. Edited by the academician of Ukrainian NAS V. Machulina.- K .: Naukova Dumka, 2014. − 152 p. (Цифрова обробка аудіо- та відеоінформації у мультимедійних системах / П.Ф. Олексенко, В.В. Коваль, В.С. Лазебний, Г.М. Розорінов, О.О. Скопа. За редакцією академіка НАН України В.Ф. Мачуліна.− К.: Наукова думка, 2014.−152 с.)

[2] Theoretical foundations of noise-immune coding. Part 1 / P. F. Oleksenko, V. V. Smith, G. M. Rozorinov, G. A. Sukach. Edited by the academician of Ukrainian NAS V. Machulina. − K .: Naukova Dumka, 2010. − 191 p. (Теоретичні основи завадостійкого кодування. Частина 1/ П.Ф. Олексенко, В.В. Коваль, Г.М. Розорінов, Г.О. Сукач. За редакцією академіка НАН України В.Ф. Мачуліна.− К.: Наукова думка, 2010. − 191 с.)

[3] Theoretical foundations of noise-immune coding. Part 2/ P.F. Oleksenko, VV Smith, GM Rozorinov, GA Sukach. Edited by the academician of Ukraine NAS V. Machulina. − K .: Naukova Dumka, 2012. − 210 p. ([Теоретичні основи завадостійкого кодування. Частина 2/ П.Ф. Олексенко, В.В. Коваль, Г.М. Розорінов, Г.О. Сукач. За редакцією академіка НАН України В.Ф. Мачуліна.− К.: Наукова думка, 2012. − 210 с.)