Development of algorithm and simulation program for audio and video information quality estimation in multimedia systems

Kalina Peeva[1], Aleksander Bekiarski[2] and Snejana Pleshkova[3]

Abstract – **This paper examine the use of program system Matlab, as a tool for creating an algorithm and a program for analysis and quality estimation of the reproduced video and audio information in multimedia systems. As a basis of development in this paper is the widespread standard for digital television (DTV). The purpose of this article is to create a simple simulation model of the DTV standard, for transmission of video and audio information. The developed algorithm and simulation program can be used for simulations of professional measurements or in students education to study the transmission of digital multimedia content with DTV standard, for additionally protected terrestrial channel, intended to secure the information against the possible existence of negative factors such as the occurrence of interference and noise in the communication channel within a chosen type of digital television system with DTV standard. Presented are the experimental results of the analysis for the reliability and the effectiveness of the applied algorithm, obtained during the simulation program.**

Keywords – **Digital television, DVB standard, Digital image, Communication channel model, Quality of video and audio information.**

I. Introduction

In the past few years the international approved standard DVB for digital broadcasting in television and video multimedia systems is successfully found wide continuity in number of areas and is earned popularity especially in the countries from EU zone [1, 2]. Depending on the signals propagation mode there are tree existing paths – terrestrial, cable and satellite – which shall comply with the technical capabilities and the audience needs. In this paper when developing an algorithm and simulation program will be use the following generalized block (Fig. 1), including the basic for the DVB system functional blocks [3], regardless of the type of transmitting channel terrestrial, cable or satellite [4, 5].

The specific characteristics of these types of video communication systems will be reflected in the simulation model by specifying the relevant parameters of the communication channel (terrestrial, cable or satellite) during the experimental verification of the proposed model of algorithm and simulation program of DVB system.

The goal of this article is to develop algorithm and simulation program for the presented in Fig. 1 the main blocks, which formed the transmitter and the receiver parts of the DVB system and to use for simulations of professional measurements or in students education to study the transmission of digital multimedia content with DTV standard.

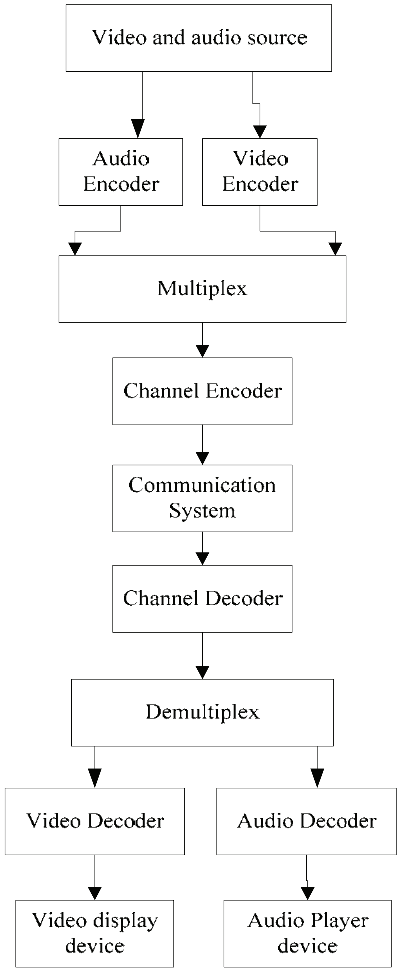


Fig. 1 Functional block scheme of DVB system

II. Approach to the developed algorithm

The developed algorithm is focused and describes the preparation of simulation model and analysis for digital video transmission and reproduction of informational signals, which meets the established standard DTV. The given test signals

[1]Kalina Peeva is with the Faculty of French Education in Electrical Engineering at Technical University of Sofia, 8 Kl. Ohridski Blvd, Sofia 1000, Bulgaria, E-mail: kala_peeva@yahoo.com

[2]Aleksander Bekiarski is with the Faculty of Telecommunications at Technical University of Sofia, 8 Kl. Ohridski Blvd, Sofia 1000, Bulgaria. E-mail: aabbv@tu-sofia.bg

[3]Snejana Pleshkova is with the Faculty of Telecommunications at Technical University of Sofia, 8 Kl. Ohridski Blvd, Sofia 1000, Bulgaria. E-mail: snegpl@tu-sofia.bg

represent the consistent data, contained in the information. Because of the requirements in the DVB standard, they are initially digitally converted in most appropriate color space YCbCr, then compressed, multiplexed together, interleaved and finally shaped by a channel coding in an output binary stream form, ready for submission in the communication channel model. All actions, support by the decoder devices in the receiver performs an opposite order, ensuring a quality video display.

The main milestones and key moments ensuring the multimedia data processing are illustrated at the main block diagram at Fig. 2. Here for the simplicity is presented only the video part of the appropriate multimedia information, assuming the similarity of the algorithm if the video information is with the accompanied audio information.

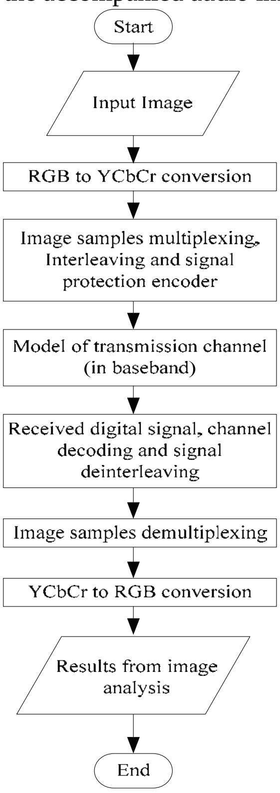


Fig. 2 Functional block scheme of processing, transmission and receiving the informational signals in multimedia system at DVB standard

One of the goals of the simulation program is the creation of a suitable functional scheme for simulation model, which will by applicable for practical realization in the specific science-oriented Sumulink space.

III. Simulation model, implemented on Matlab program system

A. Block scheme

The original input image could be selected from a file and saved in Matlab Workspace like digital uncompress content in true RGB colors as required the main resolution of DVB standard.

Fig. 3 shows the general simulation program model, developed by Matlab program Simulink system and includes the transmitter, a communication channel model and the receiver part, as follows.

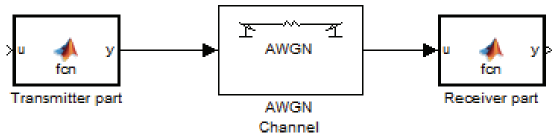


Fig. 3 Block scheme of the simulation program model for video transmission by DVB standard

The digital RGB image shall be subjected to color space conversion, which results in yielding the three separate Y, Cb and Cr components of transmission signal.

As the DVB standard supports color sub-sampling, in the simulation model has been added a bloc for color sub-sampling, which compress the two color components Cb and Cr and reduce the redundant color information. Therefore the both signals Cb and Cr for transmission are presented in color formats (like MPEG1 or MPEG2) for images, specified by the operator. Generating the multiplexed digital data sequence is individual and depends from the chosen color sub-sampling format and its application in particular case. The processed digital signals are submitted in communication channel for distribution. The output signals are recorded in Matlab Workspace as variables or matrices with names *Yout*, *Cbout* and *Crout*. The digital sequence is standardized and meets the ITU-R 601 Recommendations and generates multiplex successive frames of image. The output signals *Yout*, *Cbout* and *Crout* are multiplexed to form a completed binary signal, which is protected against transmission errors by cascade coding with Error Correction Codes and subsequent interleaves.

The described above preprocessing processes as appropriated operations in the transmitting part of the general Simulink model (Fig. 3.) are illustrated on Fig. 4.

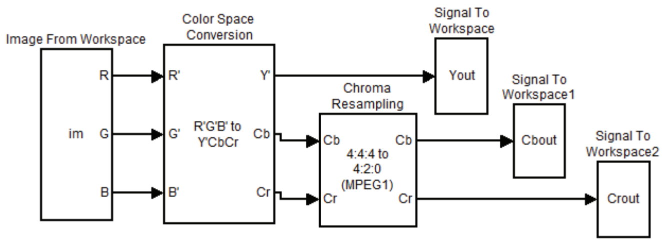


Fig. 4 Block scheme of input image preprocessing levels, composed in Simulink space

The performed in the receiving part actions (Fig. 5.) follow a reverse order to those, described in the transmission part of the DVB system. The only difference is the interpolation of video data, which depends of the used color sub-sampled format and is final step of analysis. As shown on Fig. 5, the three components of the signal are taken from the Matlab Workspace, where they are previously recorded after the signal transmission. The two color components *Cb* and *Cr* are reconstructed with the same, but opposite, values for color upsample format, as those performed by the color sub-sample format in the transmission part. After decoding, the three signal components are converted back into the original RGB color space and the received reconstructed image sequences are reproduced on video viewer.

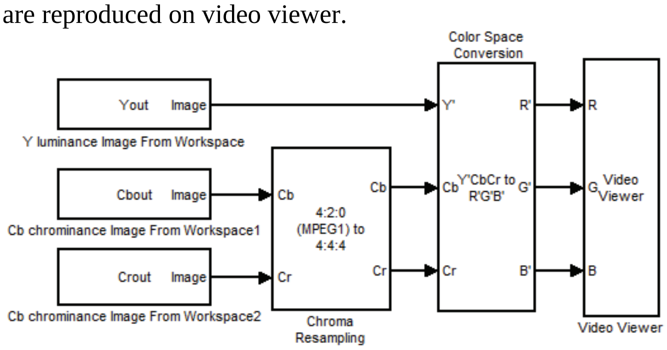


Fig. 5 Block scheme of image reconstruction levels, composed in Simulink space

B. Digital image, chosen for the developed simulation

The uncompressed digital image used in DVB model consists of three components, indicated as *Y* - component of luminance signal, *Cb* and *Cr* – sub-sampled components of color signals (Table I) with standard sampling frequency *Fs* (Table II) :

$$Y = 0.257R + 0.504G + 0.098B + 16 \qquad (1)$$

$$Cb = -0.148R - 0.291G + 0.439B + 128 \qquad (2)$$

$$Cr = 0.439R + 0.368G + 0.071B + 128 \qquad (3)$$

TABLE I
COLOR SUBSAMPLING FORMATS AND ACHIEVED IMAGE RESOLUTIONS

Format	Resolution Y		Resolution CbCr	
	horizontal [pixels]	vertical [pixels]	horizontal [pixels]	vertical [pixel]
4:4:4	720	576	720	576
4:2:2	720	576	360	576
4:2:0	720	288	360	288

TABLE II
SAMPLING FREQUENCIES AND ACHIEVED DATA RATES

Signal	4:4:4		4:2:2		4:2:0	
	F_S [MHz]	H [Mbps]	F_S [MHz]	H [Mbps]	F_S [MHz]	H [Mbps]
Y	13.5	108	13.50	108	13.50	108
Cb	13.5	108	6.75	54	6.75	27
Cr	13.5	108	6.75	54	6.75	27
MUX	40.5	324	27.00	216	27.00	162

C. Error Protection Coding in DVB

The principle of digital broadcasting, with coding against errors, in digital TV is determined by adding some extra information to the coded digital signal in the channel. Adding more information leads to increase the volume of information and requires the presence of specific channel decoder device in the receiving part. The decoder founds the position of each incorrect bit by evaluation of the extra information, which is also possibly affected by transmission errors. Two relevant methods for providing an error protection are applied, under the common name Forward Error Correction. The first is by Reed-Solomon encoding (FEC1) and the second - by convolution encoding with interleaving (FEC2) [6].

IV. EXPERIMENTAL RESULTS

The experimental results from the analysis of digital signal transmission over a communication channel model, affected by different levels of transmission errors, are briefly illustrated below. In this article only the results for video part of multimedia information are presented in form of original and received images. The results for audio part of multimedia information are also tested but are not are presented here because they usually are estimated with precisely with different subjective and objective methods, which are object of another article.

The original images are submitted using the communication channel with known error to noise ratio value defined as the ratio of bit energy to noise power spectral density *Eb/No (dB)*. It is possible to set and change the error levels, in order to follow different scenarios. Here are presented the results using two different values error to noise ratio small (*Eb/No =2,dB)* and large *(Eb/No =12,dB)*. The received color image quality is affected by the corresponding transmission errors. Fig. 6 shows the original color image, Fig. 7.a and Fig. 7.b displays the received color images for chosen values of error to noise ratio small *(Eb/No =2,dB)* and large *(Eb/No =12,dB)*, respectively and Fig. 8 presents the absolute difference between the two images (original and received), where black pixels mean the full accordance, and white regions indicate the transmission errors.

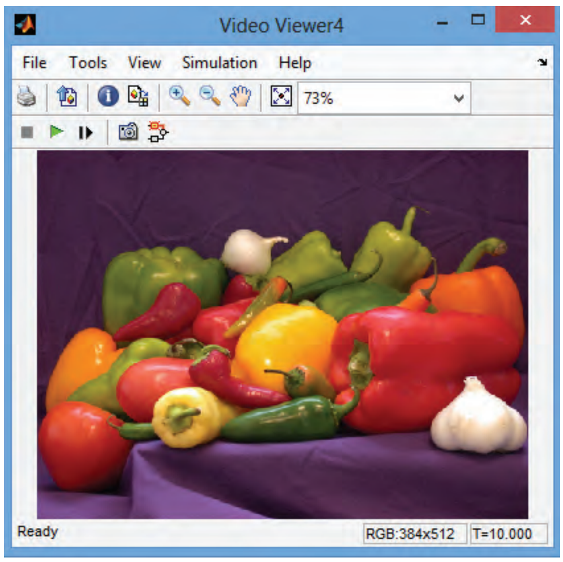
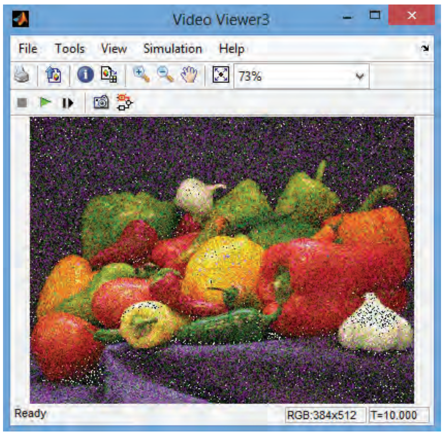
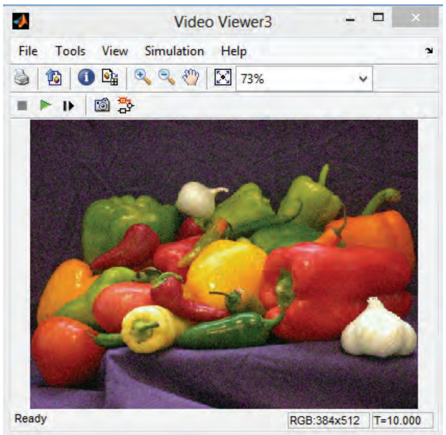


Fig. 6 Original color image before transmission over a noisy communication channel



(a)



(b)

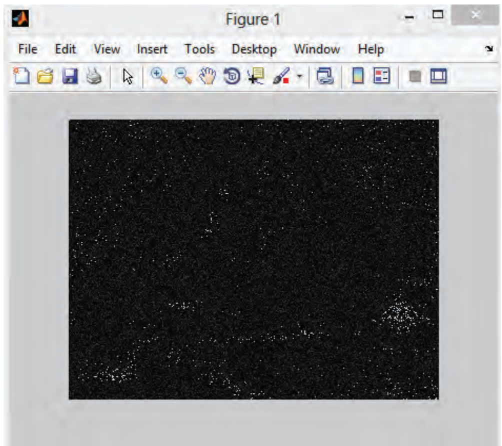
Fig. 7 Received color images, affected by transmission channel errors and noise distortions for two different values error to noise ratio (a) small *(Eb/No =2, dB)* and (b) large *(Eb/No =12, dB)*

V. CONCLUSION

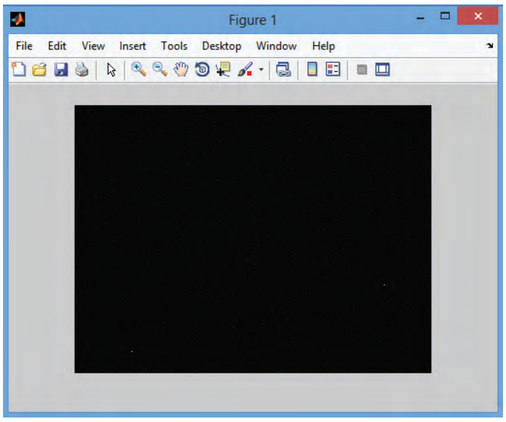
From Fig. 8 is seen that visual observation and estimation of received image quality from images of the absolute difference between the original and received images can be used because for small values *(Eb/No =2,dB)* of error to noise ratio (Fig. 7.a.) the white regions, which indicate the transmission errors are more visible compared with the same white regions for large values *(Eb/No =12,dB)* of error to noise ratio (Fig. 7.b.), where black pixels, which mean the full accordance with of received to the original images are dominated.

ACKNOWLEDGEMENT

This paper was supported by Technical University – Sofia inner program to support PhD research projects under Contract 132 PD0025-07: "Development of algorithms for quality estimation of audio-visual information in multimedia computer systems and networks**"**.



(a)



(b)

Fig. 8 Image of the absolute difference between the original and the error-affected image for two different values error to noise ratio (a) small (*Eb/No =2,dB)* and (b) large *(Eb/No =12,dB)*

REFERENCES

[1] Michael Robin, Michel Poulin. Digital Television Fundamentals (Hardcover). McGraw-Hill, 2000.
[2] Digital Video Broadcasting (DVB); A Guideline for the Use of DVB Specifications and Standards. DVB Document A020 Rev. 1, May 2000.
[3] Al. Bekiarski, Television Systems, Technical University – Sofia Press, Sofia, 2009.
[4] Dimitrov D., Velchev Y., "Communication Protocol for Medical Mobile Network" 48 Internationales Wissenschftliches Kolloquium, Ilmenau, Germany, 2001.
[5] Dimitrov D., Y. Velchev, St. Kolev, Kl. Angelov, "Infrared Measurements Signal Processing", TELECOM'2009, 8-9 October, St. Constantine, Varna, BULGARIA, 2009.
[6] Tomáš KRATOCHVÍL, Utilization of MATLAB for Digital Image Transmission Simulation Using the DVB Error Correction Codes, RADIOENGINEERING, VOL. 12, NO. 4, DECEMBER 2003.