DIFFERENT SIGNALS' PARAMETERS INFLUENCE ON IMAGE QUALITY ASSESSMENT

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Abstract

Currently, the growing number of video transmissions in mobile networks takes an increasing part over all telecommunications services usually got by mobile users. High-quality mobile video transmissions are dependent on the parameters of wireless transmission medium, so it is very important to choose the appropriate signal parameters as wireless transmission medium is particularly responsive to environmental factors. Due to this, the authors carried out the different investigations. The evaluation of different wireless signals' modulations and various noises was done in order to investigate it influence on the quality of the transmitted video images. The investigations were carried out by analyzing images of different types and compressions. The different criteria were used for the objective assessment of video quality in these investigations. The results of all investigations and it based conclusions are presented in this paper.

1. INTRODUCTION

The opportunity for users' mobility and streaming of video services to anywhere and access it content at any time is a uniqueness of wireless networks, which allows to lead in competition with wired networks. However, the streaming of high quality video services is a challenging process to the providers of wireless networks. The digital video transmission passes a number of processing stages with a variety of devices in wireless system while it reaches the end user's mobile device. Therefore, various distortions in a video stream can occur during it transmission. These distortions can be visually visible to the mobile users and can cause their negative emotions on perceived quality of video services [1]. Moreover, a high quality wireless video transmission is very challenging for multi UAV (*Unmanned Air Vehicle*) systems, such as FANET (*Flying Ad-Hoc Networks*) [2]. It is related not only to the video stream processing over different devices in the wireless systems, but with signals' parameters over different wireless transmission medium (as LTE [3], WiFi [4], *etc*.) as well. The wireless signals' modulations and wireless signal strength in the level of background noise are one of the main characteristics, which affect quality of video stream, transmitted over wireless medium. SNR (*Signal-to-Noise Ratio*), PSNR (*Peak Signal-to-Noise Ratio*), and BER (*Bit Error Rate*) are well known key parameters that are used in assessing wireless systems. The authors used these criteria in combination with objective video quality methods as MOS (*Mean Opinion Score*) for the assessment of different wireless signals' parameters influence on transmitted video quality.

So the task of this paper was to investigate the influence of different wireless signals' parameters to the quality of transmitted video stream. Based on the results of investigations, the authors recommended the approach for the video transmission process, which would help to improve the quality of video services transmission over wireless networks.

The paper is organized as follows. Section 2 describes the investigations and video snapshots of the evaluation of influence of wireless signal's parameters on quality of video images. Section 3 combines video snapshots with a graphical results and objective video quality assessment. Finally, Section 4 presents the conclusions and authors' recommendations.

2. EVALUATION OF INFLUENCE OF WIRELESS SIGNAL'S PARAMETERS ON QUALITY OF VIDEO IMAGES

The investigations were done by using MATLAB simulation platform. Three different wireless signals modulations were used:

- QPSK (*Quadrature Phase Shift Keying*),
- QAM (*Quadrature Amplitude Modulation*) - 64,
- QAM - 256.

The two types of video images with different colour basis were taken for the investigations:

- video image with cat – greyscale and size 656x368;
- video image with tucan – colourful and size 640x336.

The parameters, which authors used in investigations [4, 5]:

$$PSNR = 10\log\frac{(2^n - 1)^2}{MSE}, \quad (1)$$

$$MSE = \frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}(f(i,j) - f'(i,j))^2; \quad (2)$$

where *f(i,j)* describes original picture of the video; *f'(i,j)* – describes transmitted picture to the user mobile device; *M* x *N* – the resolution of video in pixels.

The conversion of PSNR to objective MOS value was done according [6].

First of all, the investigation of evaluation of SNR level impact to the quality of video images transmitted with different wireless signals' modulations were done. Figures 1 and 2 present visual results from this investigation. It is clearly visible, that the highest quality of transmitted video is for QPSK modulation in both figures (fig. 1-2). The increased level of SNR eliminates most visually visible artifacts from video images, which were transmitted with QAM-64 and QAM-256 modulations. However, it isn't competitive to quality of video with QPSK modulation.

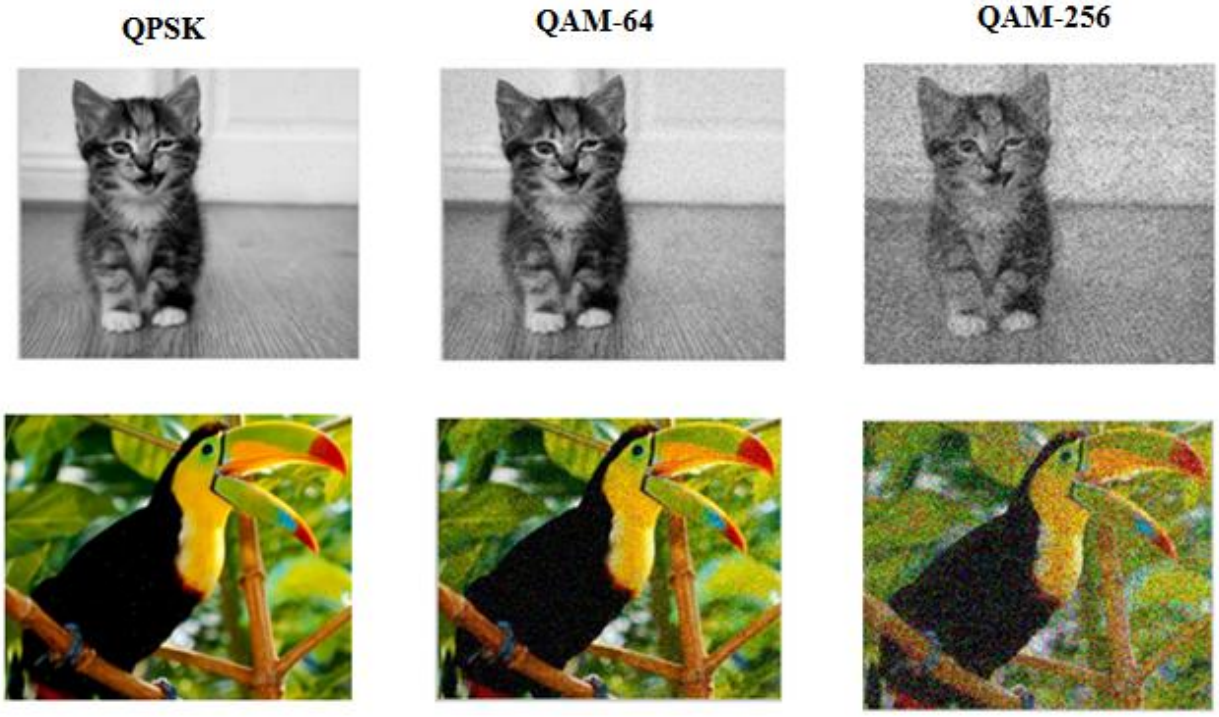

Figure 1. Video image quality for different modulation of wireless signal, when SNR=10 dB

Secondly, the authors investigated how different SNR levels can affect quality of transmitted video, when the modulation is QAM-256 (Fig. 3). This modulation was selected, because it is able to carry more bits of information per symbol in difference from others. The results of this investigation showed, that SNR level should be increased more than 3 times for the satisfying transmission of video without visual hum.

The noise level and type [7, 8] is very important factor for video transmission quality in wireless networks. Therefore, the authors investigated influence of Additive White Gaussian noise (*AWGN*) and multiplicative uniform noise to the quality of transmitted video over different wireless signal's modulations (Fig. 5).

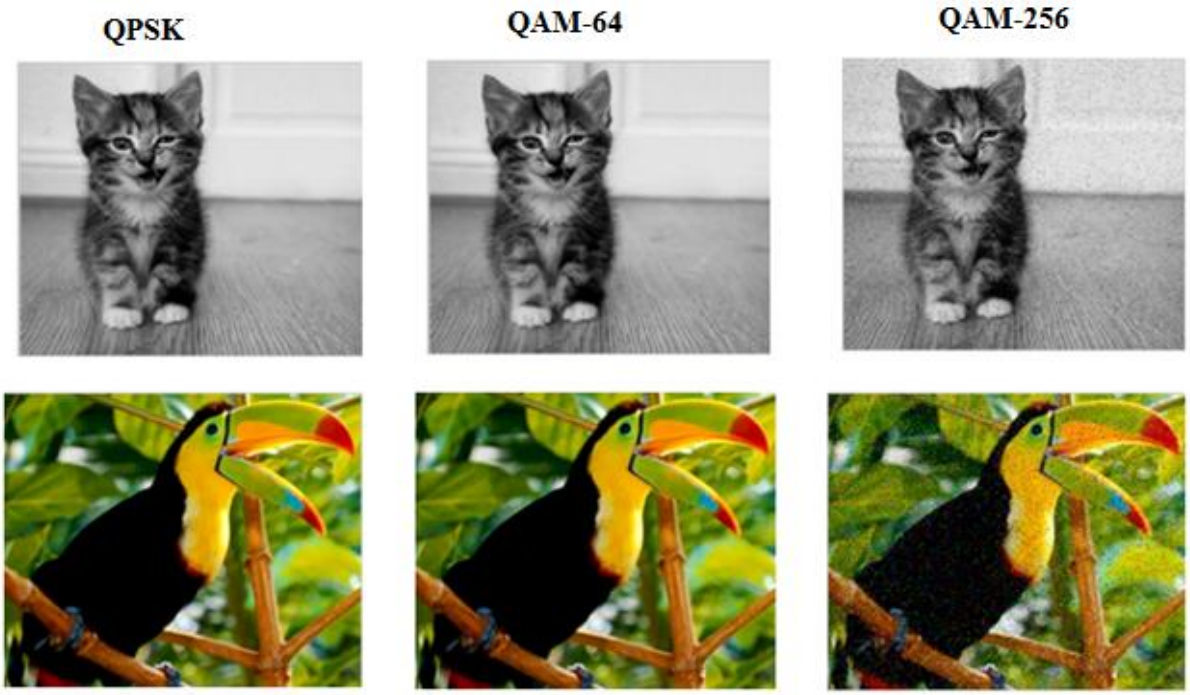

Figure 2. Video image quality for different modulations of wireless signal, when SNR=18 dB

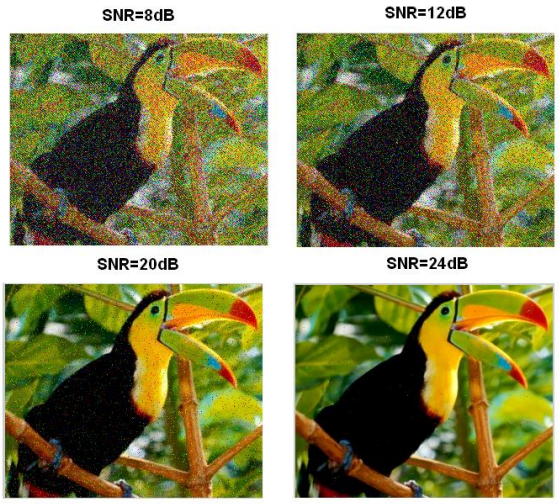

Figure 3. Video image quality for different SNR values, when modulation is QAM-256

AWGN is the effect of thermal noise generated by thermal motion of electrons in all dissipative electrical components. The results showed that AWGN more influences quality of video, which was transmitted over QPSK. The significant difference is for multiplicative uniform noise, which affect quality of video in all modulations.

Figure 4. Video image quality, when BER= 11.7882e-004

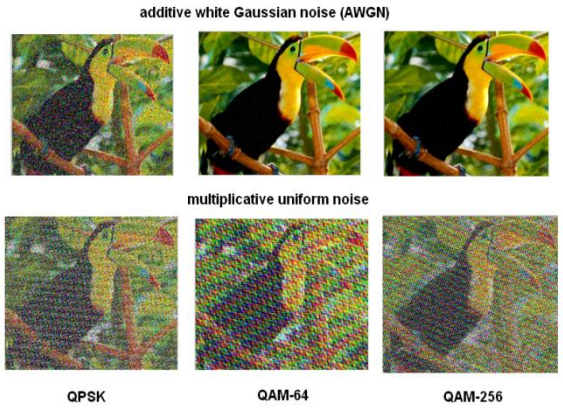

Figure 5. Video image quality for different types of noise

The last investigation was done for the evaluation of necessary SNR level for each wireless signal modulation in order to receive the video image with a good quality (without any visual artefacts). The BER criterion was used as the required maximum 2E-3 level of bit errors for perceived video of a good quality. BER is the estimated probability that a bit transmitted will be received incorrectly through a device or network. Figure 4 shows results from this investigation. It was stated, that for QAM modulation it is necessary to have several times higher SNR value in comparison to QPSK in order to have a good quality video transmission over wireless networks. In addition, it comes a recommendation for a higher SNR to ever-higher type of QAM modulation as well.

3. ASSESSMENT OF VISUAL VIDEO SNAPSHOTS WITH A GRAPHICAL RESULTS AND MOS

The visual results from the previous investigations were combined with graphical results, presented in Figures 6 and 7. Image enhancement or improving the visual quality of a digital image can be subjective. Saying that one method provides a better quality image could vary from person to person. For this reason, it is necessary to establish quantitative/ empirical measures to compare the effects of image enhancement algorithms on image quality. Therefore, we calculated parameters BER and PSNR. After that, main metric PSNR was converted to objective MOS value. The parameters of investigation - BER, PSNR and MOS - were calculated using MATLAB.

PSNR is defined as the ratio of the total number of pixels in the compressed image to the mean square error in dB. Typical PSNR over 40dB is often considered undistinguishable from the original. The lower and upper limits for PSNR are 20dB and 40dB, respectively [9].

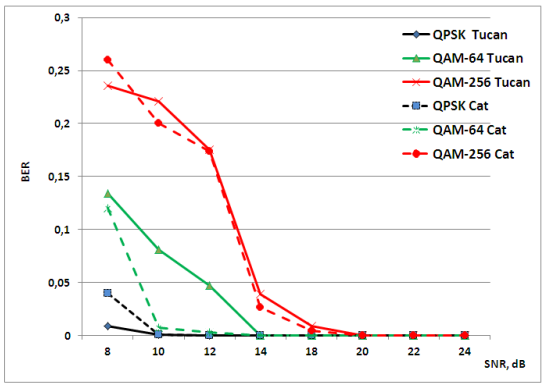

Figure 6. Dependence of BER on SNR for different quality of video images

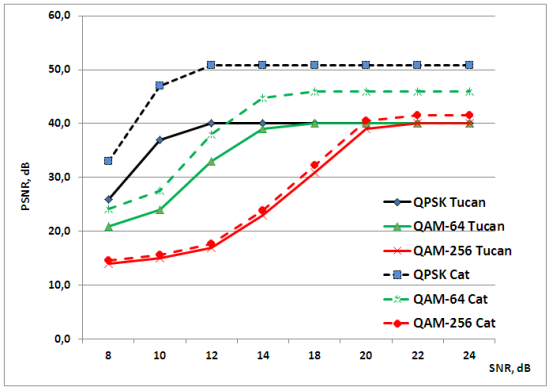

Figure 7. Dependence of PSNR on SNR for different quality of video images

In Figure 7, we can observe that PSNR values decreases when SNR is less then 14dB, because from this value increases the BER value (see Figure 6). It influences very much the quality of video image, if it was used QPSK modulation in wireless medium and was a different image compression and colour ratio. The proposal is that the higher PSNR level, the better-degraded image will be reconstructed to match the original image as well the better reconstructive algorithm will be used. This would occur because we wish to minimize MSE (*Mean Squared Error*) between images with respect of the maximum wireless signal value to the video image quality.

The dependency of MOS on SNR for different signals' modulations was calculated using the mapping between PSNR and MOS. The results are presented in the Figure 8.

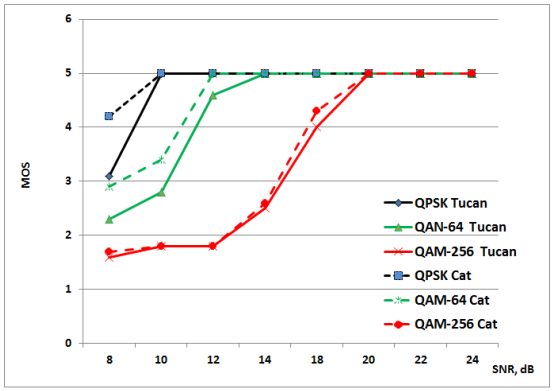

Figure 8. Dependence of MOS on SNR for video images of different modulations

As it can be seen, the higher MOS values are for the both types of video images, which were transmitted with QPSK modulation. The worst evaluation of video quality is for video images with QAM-256 modulation. This leads to the conclusion that using of QAM modulation for a video streaming over wireless networks increases the probability of errors in all video streams. And this impacts to the appearance of annoying artifacts visible during the wireless video transmission, which affect the subjective assessment of video quality (to a lower grade of MOS) by the mobile users.

4. CONCLUSIONS

The investigations for different signals' parameters influence on image quality assessment showed, that the wireless signals' modulations affect quality of transmitted video images in different ways. The lower signal modulation, as QPSK, will be used for a video transmission, the better quality of video the mobile user will receive. However, the lower signal modulation will gives a lower data rate of a wireless link, which also will cause a negative impact on the mobile users' visual perception and emotions. QAM-64 or QAM-256 modulations give a higher data rate for a wireless video transmission, but it impacts the quality of transmitted video images in several times. This is because the higher modulations are less resilient to noise or interference over wireless transmission medium. Due to this, the main recommendation is to balance the level of SNR for an ever-higher type of signal modulation in such way, that it could improve the quality of transmitted video images in a positive way. The level of SNR should be increased for an ever-higher type of wireless signal modulation.

5. ACKNOWLEDGMENT

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