Derivation of numerical criteria for the occurrence of natural phenomena in video sequences

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Abstract – **In this paper are presented the results from an analysis of the information, obtained from dataset of one year video records. The results show that some natural phenomena could be detected by simple numerical criteria. The records have been taken by outdoor surveillance cameras. The applied data processing aims to determine criteria for the occurrence of events affecting the visibility in images. The technique uses dark channel prior images (DCPI) and correlated color temperature (CCT) for limited areas located at identical positions within consecutive frames.**

Keywords – **natural phenomena in images, numerical criteria, video sequence analyses, visibility in the images.**

I. Introduction

The creation of automated real-time systems with computer vision requires a lot of observation and analysis. Especially in case of variable environmental conditions. Natural phenomena such as darkness falling, the appearance of a blinding light source, the presence of fog, heavy snowfall or rain lead to a loss of visibility in the images. This requires that the initially collected data set cover conditions during different seasons of the year and at different observation locations. There are several static image databases [1,2] that can be used to test image quality improvement methods and algorithms. However, natural phenomena have one peculiarity – they do not appear consecutively in areas of the scene captured at different distances from the camera [3]. The aim of our research is to predict the loss of visibility by tracking different areas (patches) in successive frames. That is why, we use a scheme for positioning observed patches in images shown in Figure 1.

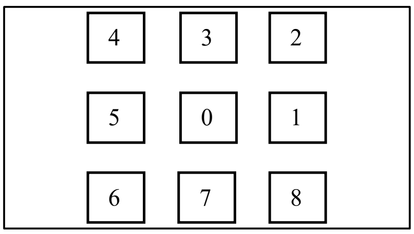

Fig. 1. Numbering and relative positioning of patches in a single image

In our previous study [4] we tested the effect of different size of patches on the tracked parameters. The most suitable size is the maximal size for which there is no overlap.

The published analyses for classification schemes creation use statistical evaluation of certain parameters in digital images [5,6] and mainly advanced neural networks [7,8]. The most evaluation parameters are based on the mean value of the lightness and its deviation in the images. In our development, the mean value of the lightness, and its deviation are calculated for each patch in gray scale images (DCPI) composed of the minimal component of the red, green, blue (RGB) color reproduction signals for each pixel. The use of DCPI is not new and is still relevant [6] for images' visibility research. Our previous analyzes [4] show that, same weather conditions give a similar trend of the mean and deviation determined by the minimal component as their calculation using the three RGB signals. The other parameter in this study is correlated color temperature -CCT, data for which is taken at the process of DCPI creation. We also use [4] the simultaneous parameter deviations for each patch relative to a preselected one to track the dynamics of natural phenomena. The aim of this work is to test the possibilities of finding numerical values of parameters that allow the detection of phenomena affecting the visibility of the registered images.

II. Theory

The standard ISO 15076-1 [9] "Image technology color management", establishes the requirements for color exchange between digital devices. According to it, outdoor cameras are calibrated to sRGB color space. That means fixed white point, triangle of chromaticity, gamma correction and fixed coefficients for transformation to basic CIEXYZ system for all registered signals of the camera. This makes it possible to apply the same processing and compare the results using records obtained from different devices.

The phenomena searched here such as darkness and blinding reproduce numerical values in the lower and upper limits of the dynamic range of registration. In both cases, the colors lose saturation, that brings the values of the minimal and maximal reproducing components closer together. Thus, any changes of the lightness will be reflected similarly in the minimal component for each pixel, that the DCPIs are composed.

The fall of darkness brings out low values of the registered signals, and chromaticity information, determined by the ratio of color reproducing components, is difficult to extract. Since automatic gain in the camera is based on overall lightness [10], different areas in the image are most likely to be colorless, and objects appearing at night can be

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reproduced with chromaticity if their colors are highly saturated. On the other hand, a mark for discoloration is a CCT value closer to the white value set in the camera calibration. Also, the presence of a bright light source in any part of the scene would cause "blinding" for the patch in that area. How the darkness will change the monitored parameters and which of them are significant can be determined only on the basis of real images. For daylight hours, the presence of a blinding source implies changes in both the mean value of the lightness and its deviation, and loss of visibility of details. Thus, the events that could be possible to characterized by numerical values of the monitored parameters are:

- the fall of darkness,
- sunrise,
- a light source in a monitored field.

In addition, these phenomena need to be distinguished from the loss of visibility due to fog, rain or snowfall.

III. EXPERIMENTS, RESULTS AND DISCUSSION

A.Experimental setup

The created database of video sequences was analyzed for fixing the moment of total darkness, sunrise, natural light source falling into a patch. The values, obtained for the parameters, were compared with those in the presence of dense fog.

In the present observations, we used a database accumulated over one year at different annual seasons from the same outdoor video cameras [11]. The cameras are located at NAO Rozhen – object Rozhen and Varna city-object Varna. For each location, the number 3 patches cover only the sky without additional details, and those with the number 7 show the areas closest to the camera and include ground-based objects. Each sequence covers a time period of 24 hours, represented by snapshots taken every 30 seconds. That means - the light and dark hours of the day. The obtained results are based on analysis of a total of 109 sequences.

The derivation of numerical criteria is done with the help of specially developed software using the OpenCV library resources. The implemented functionalities are as follow:

-selection of a frame from the video sequence;

-restriction of the fields in each frame (at the sizes of the frames in the used series, the patches are limited to 128 x 128 pixels);

- calculation of CCT for each patch (the algorithm shown in [4] was used);

- converting the patches into a DSPI by selecting the minimal reproducing component;

- calculation of mean value of lightness (**average)** and its deviation (**deviation**);

- calculation of relative values of parameters to a fixed patch (here is used patch numbered 8) – dAv for average, dDev for deviation and dCCT for the correlated color temperature.

B. Results and discussion

Tracking of the data from the nine patches in the frames showed darkness occurring at values for CCT 5459K and a difference in color temperatures dCCT=0, for all sequences. Similarly, the sunrise – onset of daylight hours, is characterized by CCT values different from 5459K and non-zero differences for dCCT. The moment of sunrise was determined under different meteorological conditions, and is given in Table 1.

TABLE 1. NUMBER OF DAYS BY MONTH WITH UNIFORM CONDITIONS AT SUNRISE

Clear	Light clouds	Cloudy	Foggy
Object Rozhen			
2022 April - 8 May -12 July -3 October-1 Nov. -1 2023 Jan. -1 Feb. -1 April -2	2022 May -3 Dec. -1 2023 April -3	2022 April -2 May -4 June -4 Nov. -1	2022 April -3 May -1 June -1 Nov. -2 2023 Jan. -1
Object Varna			
2022 April -4 May - 9 June -3 July -1 2023 Jan. -1 April -2	2022 May -2 July -1 Nov. -1	2022 April -9 May - 9 June –3 July -1 Nov. – 3 Dec. – 1 2023 April -3	2022 Oct. -1
Total number of days			
49	11	40	9

Tracking of frames in darkness and fog show a difference in values for CCT and dCCT. They are not zero if the lack of visibility is due to the presence of fog. This is a result of the difference in fog density for the different distances between the camera and the objects for the specific location of the patches in the images.

The other tracking of loss of visibility involves the presence of a light source in one of the patches. For the period of darkness, the moon is the main appearing source. The moon size could also be different. Figure 2 shows images of a pair of patches in which the moon is occurred. In figure 3 are shone a graphics of the average of the lightness in DCPI and CCT in consecutive frames. It can be seen that the presence of a blinding moon in the field only affects lightness. The same is given in figures 4 and 5 in case of larger size of the moon. Blinding gives same effect in both cases of different sizes.

The appearance of the sun in different patches is presented as pictures in figure 6.

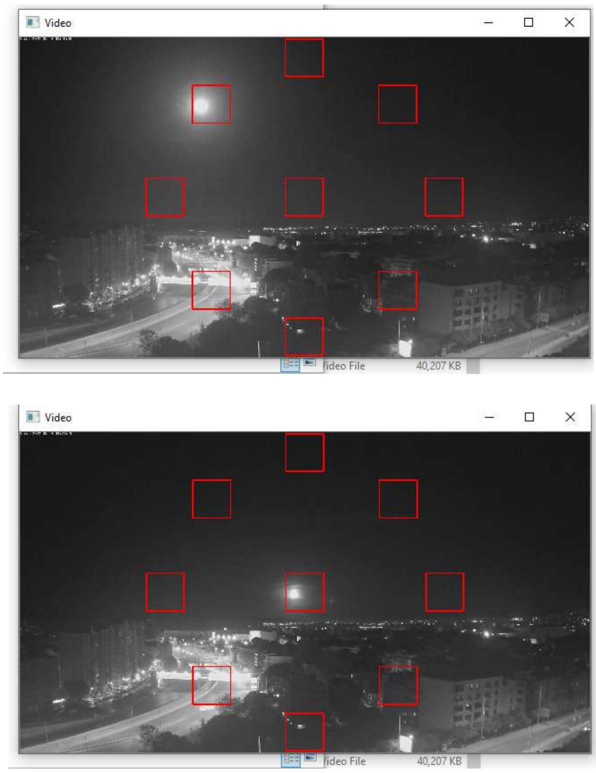


Fig. 2. Positioning of the moon in patches 4 and 0 – object Varna

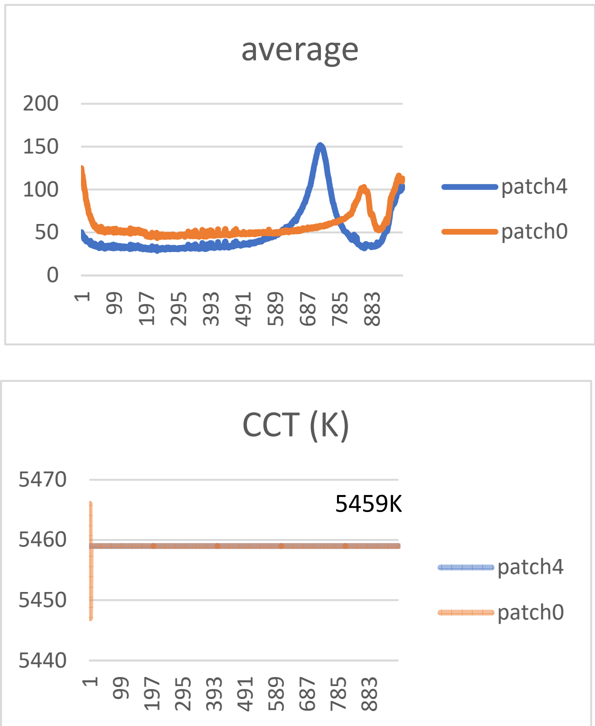


Fig. 3. Changes of average lightness in DCPI and CCT for consecutive frames – object Varna.

Fig. 4. Positioning of the moon in patch 0 – object Rozhen

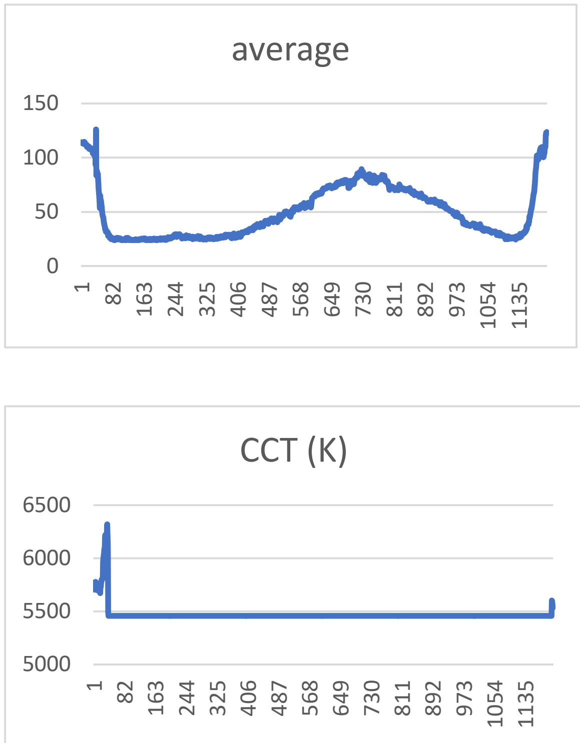
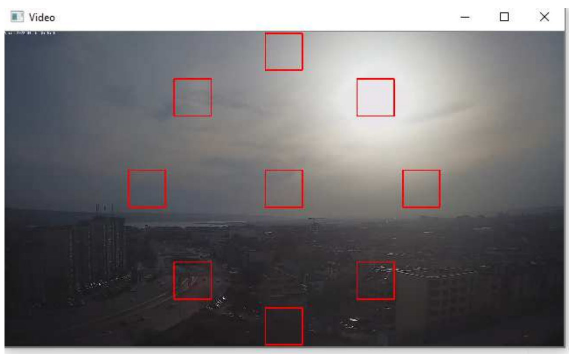


Fig. 5. Changes of average lightness in DCPI and CCT for consecutive frames in patch 0 – object Rozhen.



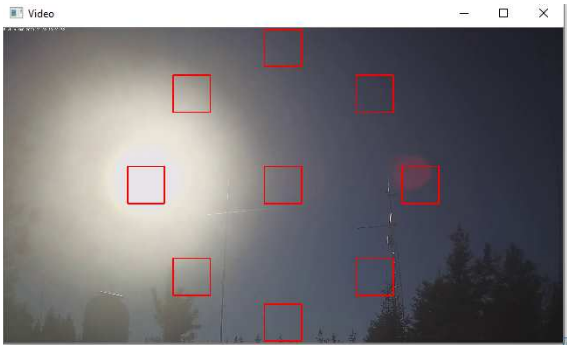


Fig. 6. Positioning of the sun in patches 2 and 5 – object Varna and object Rozhen

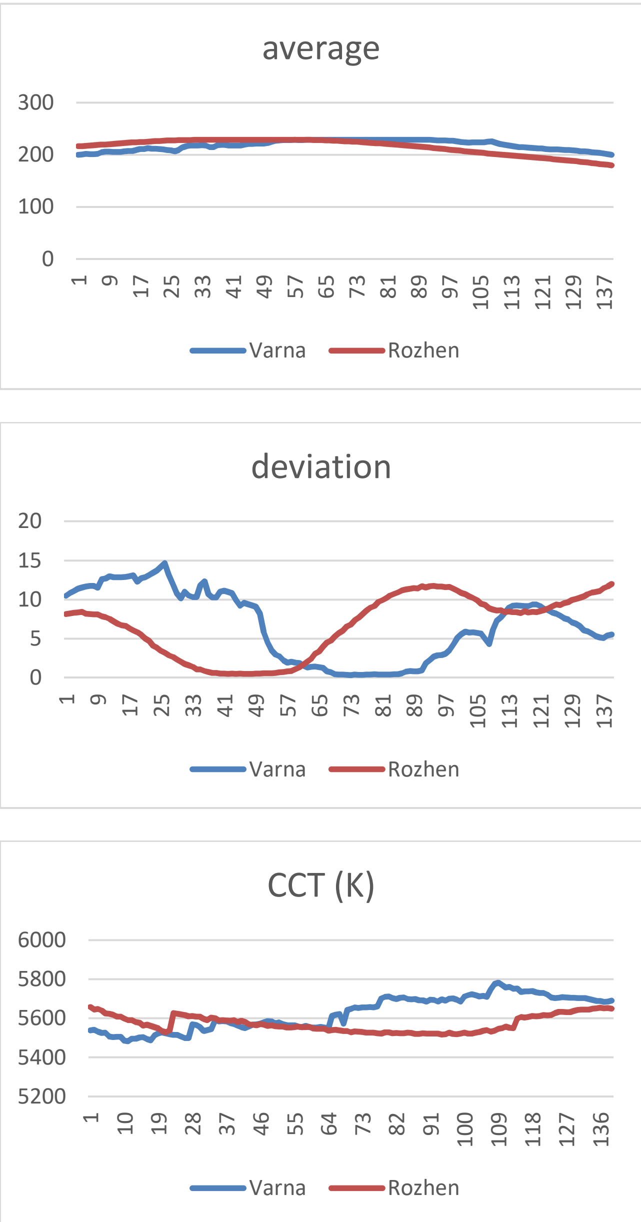


Fig. 7. Changes of average lightness and deviation in DCPI and CCT for consecutive frames with sun appearance in patches 2 and 5 – object Varna and object Rozhen.

Analysis of the parameter data shows specific values of the deviation in "blinded" patches - below 1.0, and similar values of the average and CCT parameters. Figure 7 gives the changes at values for both locations.

The appearance of a blinding source and the loss of visibility due to fog have a similar manifestation in the tracking parameters. There is only one peculiarity – the deviation for dense fog has higher values that are close to 10. Figure 8 gives the values of the deviation of lightness in DCPI for the three vertically positioned patches in both locations during dense fog. As it could be expected – the nearest to the camera patch has a higher level of the values.

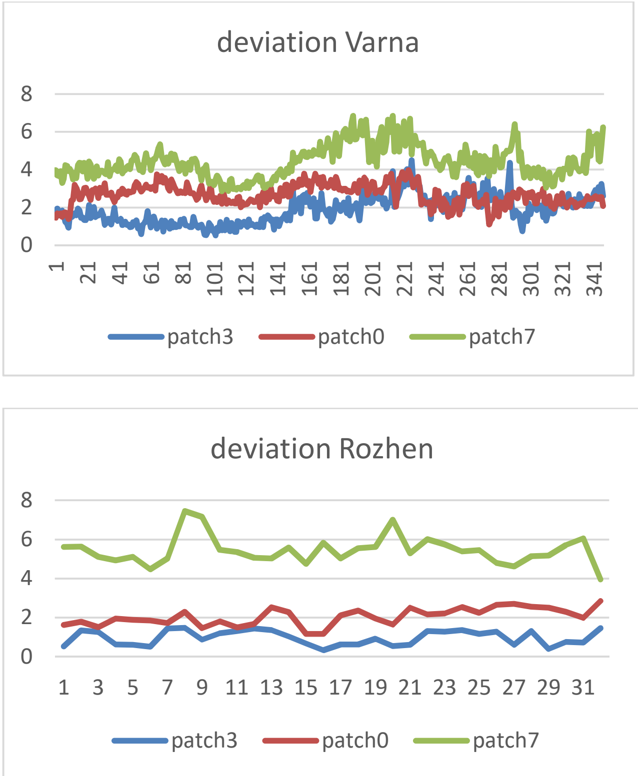


Fig. 8. Changes of deviation of lightness in DCPI for consecutive frames with dense fog – object Varna and object Rozhen.

The analyses show that mentioned above phenomena are distinguishable from the phenomena in the dark hours by the value of relative CCT difference (dCCT).

The values for significant parameters are summarized as numerical criteria for availability in table 2.

TABLE 2. NUMERICAL CRITERIA

Phenomena	Value of the parameter:			
	average	deviation	CCT(K)	dCCT
Darkness	-	-	=5459	=0
Sunrise	-	>1	≠5459	≠0
Avail. moon in the patch	Increase	-	=5459	=0
"Blinding" due to the sun	-	<1	-	≠0
Dense fog	-	<10	-	≠0

II. CONCLUSION

The results obtained make it possible to develop algorithms for monitoring the occurrence of specific natural phenomena. The software used to extract values for the parameters in the observations can be upgraded to a main component in a system for tracking dynamic change of visibility as a consequence of changing weather conditions. An important characteristic of such type of real-time automated systems is their performance DCPI, composed of minimum values of color reproduction signals for a pixel, gives another advantage - speeding up the calculation process. The OpenCV library offers many opportunities, but also a lot of limitations. The possibilities for optimization of the program implementation can be summarized in three directions [12]:

- Using data types according to the bit rate of the computing processor and appropriate operators performing the necessary arithmetic and logical operations,
- A use of dynamic variables, dynamic allocation and free up memory. The presence of dynamic variables in the program implementation and of memory allocation and release functions implies the possibility of optimization of the code by replacing them,
- Optimizing the used library functions in terms of speed and creating your own dynamic specialized library serving a real-time system.

All that has been mentioned goes into the guidelines needed for the next stages of this study.

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