Novel Approach to Intelligent Video Surveillance System Illumination Measurement

Jiri Sevcik, Petr Svoboda

***Abstract*—** Intelligent Video Surveillance Systems (IVSS) have been increasingly utilized as a tool to ensure security in growing amount of applications. The percentages of the areas which are covered through Video Surveillance Systems are continuously increasing. The various evaluation techniques are utilized in order to manage their effectiveness. The comparison study of lighting measurement possibilities are provided in this research paper. For the purposes of this experiment the case study of real IVSS design was realized. So the results were measured in environmental conditions equivalent to central climate zone. Magnitude and reason of such measurement is discussed in the initiate part. The second part is aimed to presentation of methods and instruments utilized for measurement. The particular results obtained within the two case studies are provided in final section, where two methods of measurement were utilized.

***Keywords*—** Intelligent Video Surveillance System evaluation, illumination measurement methods, comparison study, evaluation, Image functional properties.

I. INTRODUCTION

ONE of the key functional properties of Intelligent Video Surveillance System (IVSS) is their image acquisition capability. Although the IVSS effectiveness is influenced by complex variety of factors, the most important are lighting conditions within the scene exposed. This fact is obvious even from camera working principle. The Image Acquisition properties of the cameras are continuously increased by the IVSS manufacturers on one hand, but the effectiveness of the IVSS could be increased throughout the exact specification of influencing conditions on the other hand.

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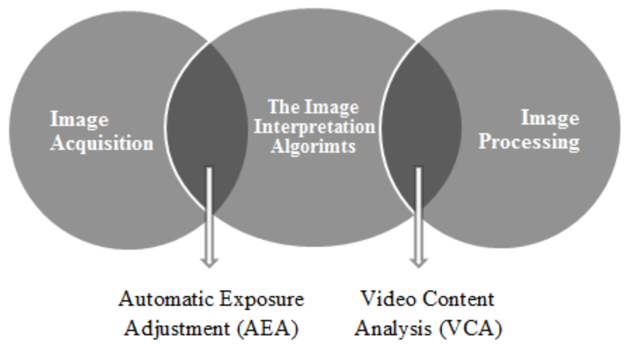

Figure 1: Image Interpretation Algorithms utilization

Moreover, Image Acquisition is an initial step within the image capturing process which means, that all next steps are influenced by the quality of input signal generated under particular conditions applied. Final scheme exposed scene lighting conditions could be managed even within IVSS design process, where two approaches could be utilized:

- Empirical (based on "know how" of particular system designer),
- Exact (based on measurable values).

Appropriate assessment of lighting conditions is closely related also to intrinsic and extrinsic calibration of the camera.

The Image Interpretation Algorithms are utilized in order to increase evidence value of image sequence captured by the system. These functions are well known as an Automatic Exposure Adjustment tools. Although particular research papers discussed evaluation of the Image Acquisition process [1], the majority were aimed to evaluation of overall architecture of the system [2], including all functional blocks such as Image Acquisition, Connections, Image Processing, Activity and data management, connections with other systems, the system and data integrity.

Content of this research paper is logicaly divided into four chapters. In the initial chapter the incident and reflected lighting intensity measurement methods are described in detail. The description of measuring instruments is provided in next chapter and the results taken from two case studies are presented in final chapter of this research paper.

II. EXPOSED SCENE LIGHTING CHARACTERISTICS MEASUREMENT METHODS

Three approaches to the lighting intensity measurement are utilized for the purposes of IVSS proposal procedure.

- Incident illumination intensity measurement,

- Reflected illumination intensity measurement,
- Histogram expertise technique.

Measurement of lighting is sophisticated engine to the exposure conditions establishment process. In case of IVSS it is necessary to divide exposed area to partial block. Advantage of this solution consists in establishment of concrete lighting level in particular partial block of the scene and its monitoring within the day. There is possible to settle severity of the scene exposed in light of the dynamic range, which is important parameter for equipment solution. Illumination is a photometric magnitude which is defined as a luminous flux incident on particular surface. Its base value is Lux. The illumination intensity is in virtue of following equation:

$$E = \frac{\Delta\Phi}{\Delta S} = \frac{I}{r^2} \qquad (1)$$

Where [E] = Lux (lx), - luminous flux, - is exposed area, I – luminance, r- range between surface and source of illumination.

Nonetheless, the equation before is usable only if the lighting incident vertically on the surface, but this case is not so common. More frequent is other case, when the lighting incident angle-wised randomly. Then is in virtue of following equation:

$$E = \frac{I \cdot \cos\alpha}{r^2} \qquad (2)$$

Where α - randomly wised angle of lighting incident.

Considering equations above is obvious, that illumination intensity is depended on range between source and illuminated object and on the lighting incident angle. Common illumination levels are illustrated via next table 1:

Table 1: Common real-life illumination levels

Illumination intensity [lx]	Level of illumination within exposed scene
100 000	Direct sunlight
50 000	Sunny weather
5 000	Overcast
500	High quality illuminated surface etc. office
300	Minimal illumination needed for reading
100	Insufficiently illuminated surface
60	Day illumination of aisles
15	Quality illuminated streets at night time
10	Evenfall
5	Common illumination of off-street
2	Minimal security illumination
1	Sunset
0,3	Full moon
0,1	Overcast moon illumination
0,001	Common stars illumination
0,0001	Low stars illumination

Alternative method of lighting characteristic is reflected illumination intensity measurement. Instead of incident illumination intensity, where the lighting beams coming on surface are gathered for measurement, in case of reflected illumination intensity are the lighting beams reflected from surface utilized and evaluated. This method has several advantages, but also similar number of disadvantages. Main advantage consist in their ability to take into account the reflection characteristic of materials which are situated in exposed scenery. The lower accuracy of measurement is then disadvantage on the other hand. Both of introduced methods are usable before the IVSS´s design itself, nonetheless the last one, the histogram expertise is based on revision of existing camera views. Core contribution of lighting characteristic is to specify dynamic range severity of the scene. The difference between the lightest and the darkest point within the image. The absolute magnitude is defined through this relationship, whereas the total amount of lighting occurring on the image sensor is described. The maximal amount of shades, which image sensor could recognize is then defined as a contrast value. Borders of image sensor are stated by capacity of each photo-sensitive cell and also the noise generated. The exposure value are established in EV magnitudes as a difference of the lightest EV in opposite to the darkest EV.

III. Measurement instruments description

Two types of measurement instruments were used within the experiment. The first one is a representative of lux meter category Sonel LXP 1. The second instrument which were used is able to measure incident and also the reflected illumination, this capabilities are at disposal by expose meter Sekonic LITEMASTER L-478DR. Technical parameter of each are illustrated via tables 2 and 3.

Table 2: Digital Luxmetr Sonel LXP 1 technical specification

Display	Multifunctional LCD	
Measuring scales	400,0 lx 4000 lx 40,00 klx 400,0 klx	40,00 fc 400,0 fc 4000 fc 40,00 kfc
Measuring rate	1,3 lx / sec	
Interrelations (lux / fc)	1 lx = 0,09190304 fc 1 fc = 10,76391 lx fc = foot candle	
Internal memory	99 measuring results	
Data logger	16000 values	
Supply voltage	9 V (accumulator)	
Dimensions	170 x 80 x 40 mm	
Weight	390 g	

Table 3: Sekonic LITEMASTER L-478DR technical specification

Measuring methods	Incident | Reflected
Special functions	Brightness difference | Memory
Lighting measuring	Ambient | Flash
Measuring scale (EV)	-27,9/+55,8EV
Sensitivity	3 - 409 600 ISO (1/3EV)
Iris	f/0,5 - f/161,2
Exposure time	30min - 1/64000 sec.
Frame per sec	1 až 1000 fps
Aperture angle	1-358°
Candela/m2	1,0-980 000
Supply voltage	2x AAA Accumulator
Dimensions	57x140x26mm
Weight	130 g

IV. IVSS Lighting Characteristic Measurement Case Study

Incident and reflected illumination intensity is influenced by several aspects:

- weather conditions within the scene (overcast, semi-bright, bright weather),
- time of measurement (three hours interval between single measurements),
- camera position considering sun position (sunrise, sunset),
- considering shadows (dropped by buildings or trees)
- positioning and timing of artificial lighting.

A. *Illumination intensity effected by various conditions*

Because of the similarity of results taken within the particular levels of detail of the scene, the time of measurement and weather conditions dependence were utilized as main grading criteria. Measured results are digestedly illustrated via following figures:

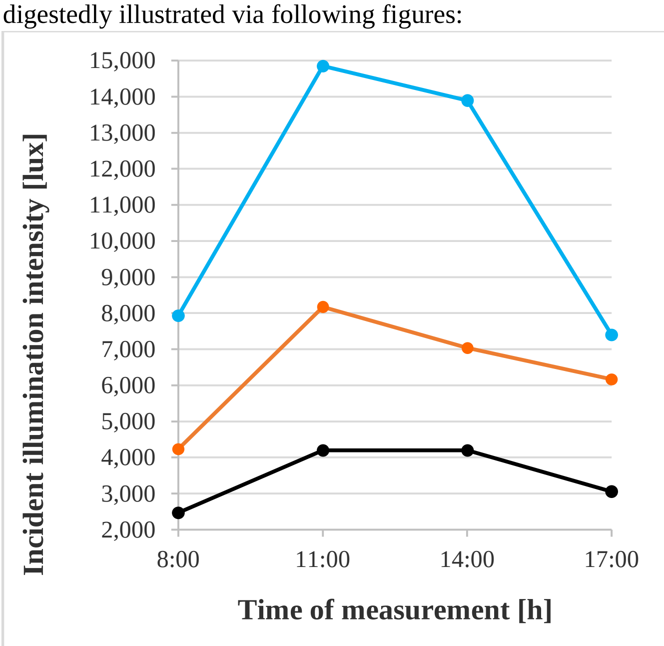

Figure 2: Incident illumination intensity within a day

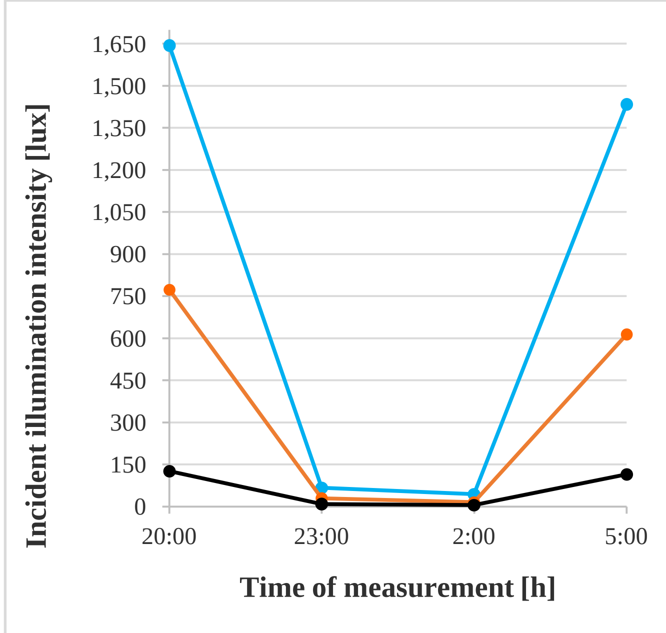

Figure 3: Incident illumination within a night

Shape of the graph curve of reflected illumination intensity does not differ considerably from the incident illumination intensity curve, on the other hand differences in particular values occurred, especially in case of reflected illumination measurement in sunny weather. They differ only in the measured values, which are reflected by light in the most of cases, especially in sunny weather, which are much higher.

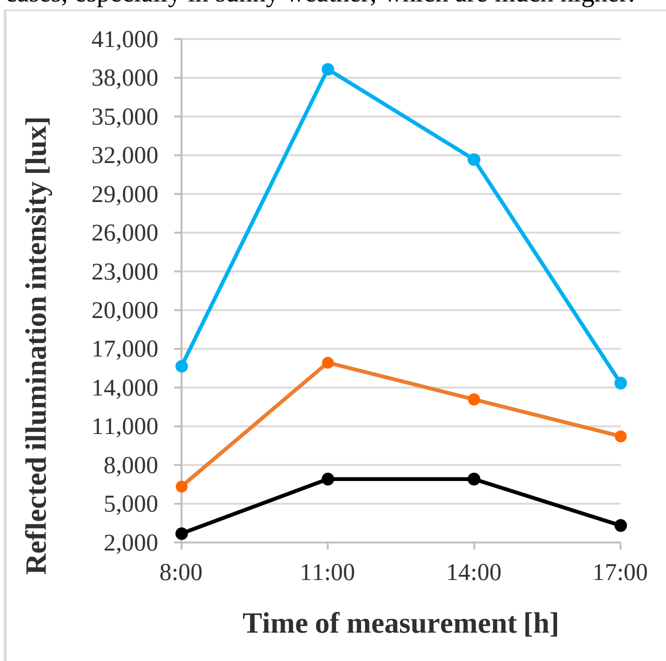

Figure 4: Reflected illumination within a day

Where bright weather is represented by blue line, semi-bright is represented by orange line and overcast is represented by black line. Technical ways of interconnecting the individual applications can be divided
into the following basic groups:

- hardware methods of integration,

- software methods of integration [3].

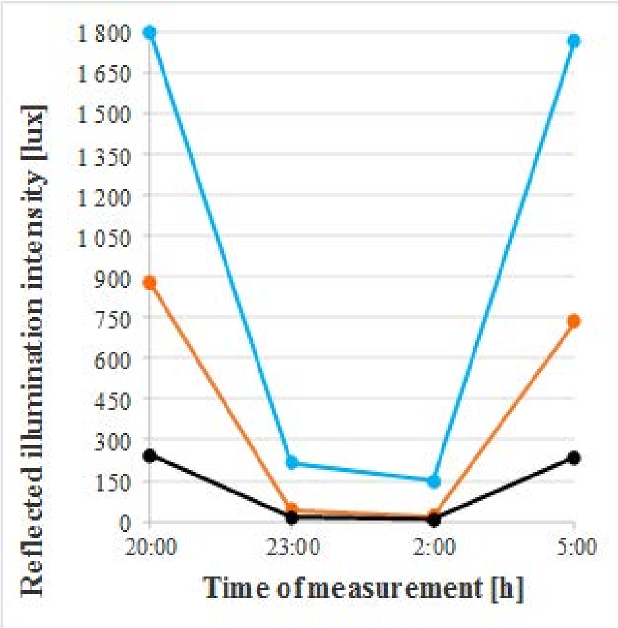

Figure 5: Reflected illumination within a night

From figures n.2, 3, 4, 5 is obvious, that characteristics of incident and reflected illumination were not significantly different. The most distinct aberrancy was investigated when measurement was accomplished during sunny weather. In these situations a value of reflected illumination was slightly higher. It is important to mention, that the most significant value differences were measured within a day. Form the results is obvious, that the reflected illumination measurement method is effective and more precise, when the highly contrastive scene is investigated. When it is necessary to measure dynamic range disposals, the reflected lighting method is considerably useful, within the IVSS design process. However, this comparison study is helpful mainly for definition of measurement methods for complex IVSS evaluation methodology, which should be proposed within the thesis of the first author of the paper.

B. Illumination intensity within particular level of detail

Cameras with various illumination intensity within particular level of detail were utilized for purposes of this measurement method. The particular ones were chosen based on characteristics of scene exposed. The experiment was realized for three levels of detail:

- observation (black curve),
- recognition (orange curve),
- identification (pink curve).

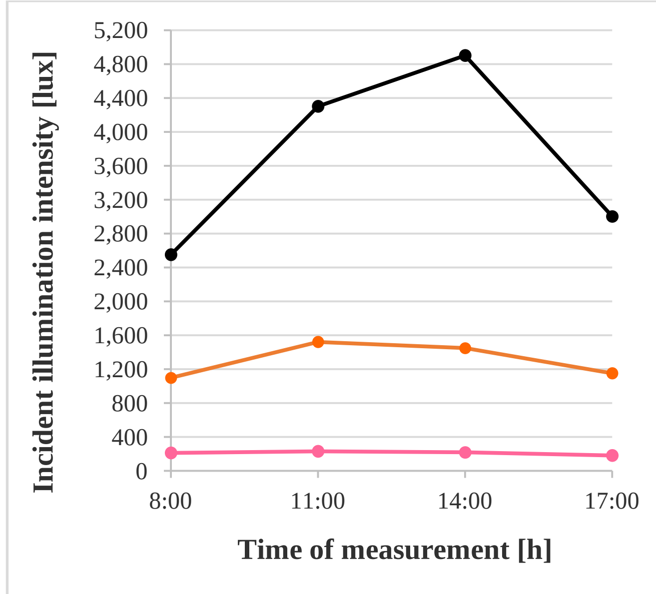

Figure 6: Incident illumination intensity in particular levels of detail in overcast day conditions

The individual charts we can see that at each level of detail the illumination intensity varies. The difference in intensity is caused by different amount of incident illumination into the different levels of detail. For particular cameras the identification level of detail is obscured by the roof and thus there is no direct impact of solar radiation in the daytime sky. Recognition level of detail is only partially covered by a roof. Last observation level is exposed to direct sunlight.

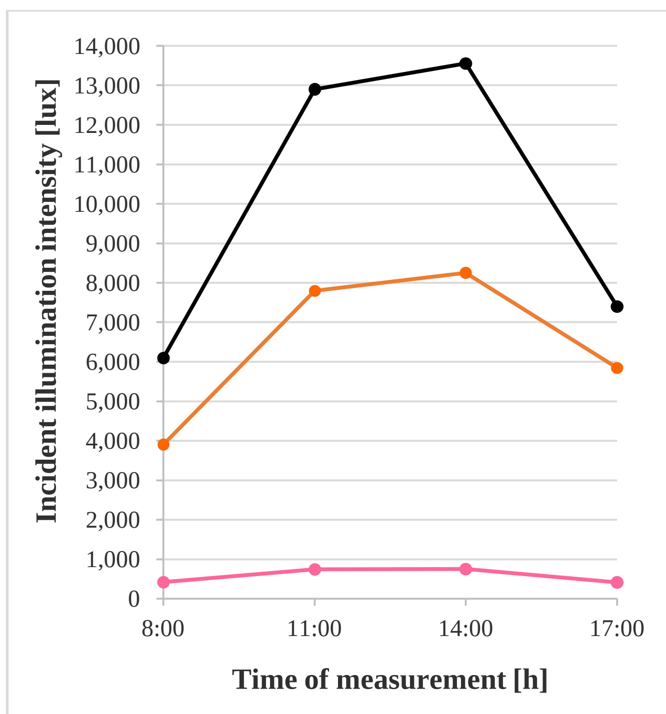

Figure 7: Incident illumination intensity in particular levels of detail in semi-bright day conditions

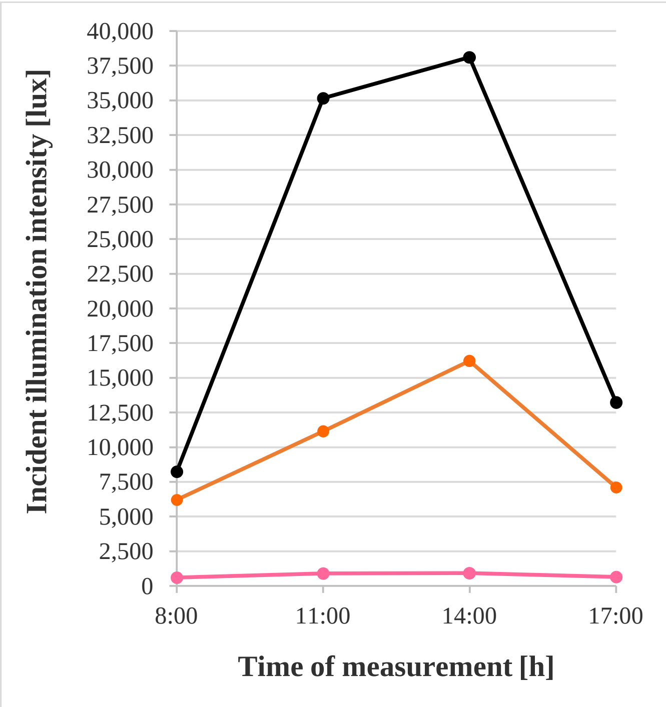

Figure 8: Incident illumination intensity in particular levels of detail in bright day conditions

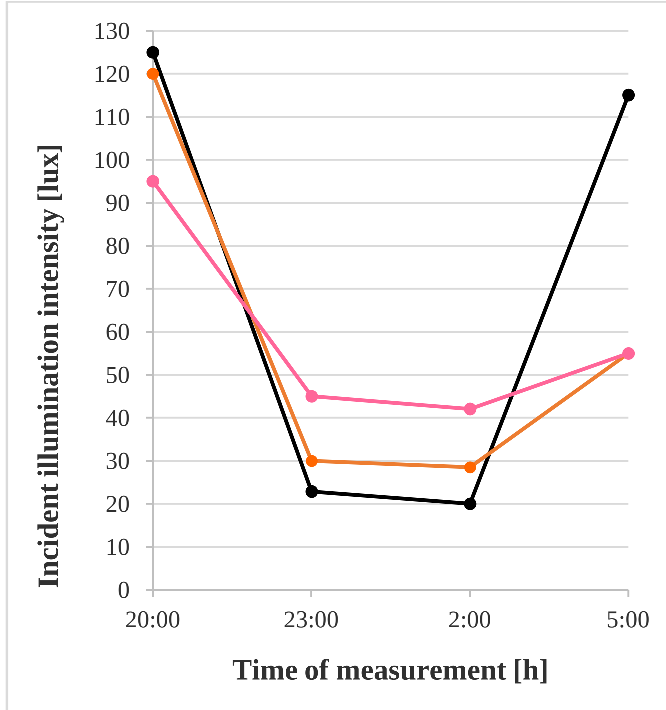

Figure 9: Incident illumination intensity in particular levels of detail in overcast night conditions

On the charts with intensity at the night sky, however, we can see that the individual curves are inverted. It is possible to state that illumination value at the identification level of detail, are greater than the intensity measured on recognition and observation level of detail. It is caused by the placement of artificial lighting on the covered part of the scene. The observation level of detail area was the most distant from the artificial lights illumination source, and therefore the measured values were the lowest.

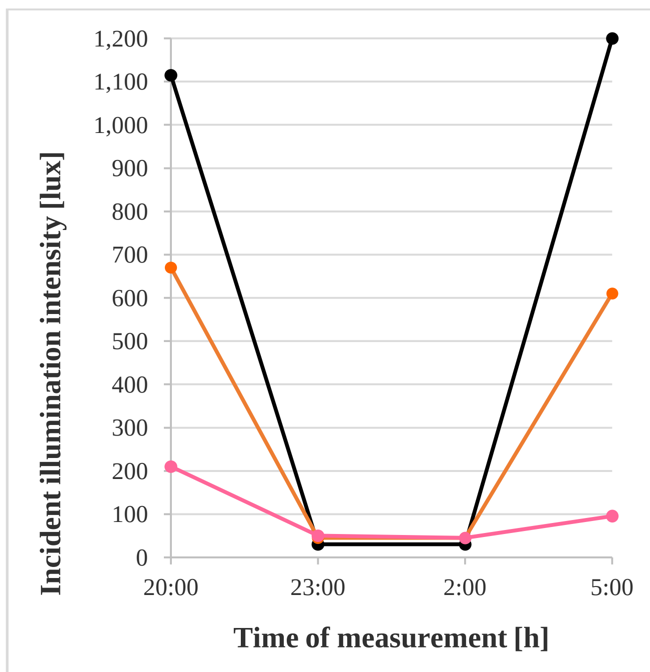

Figure 10: Incident illumination intensity in particular levels of detail in semi-bright night conditions

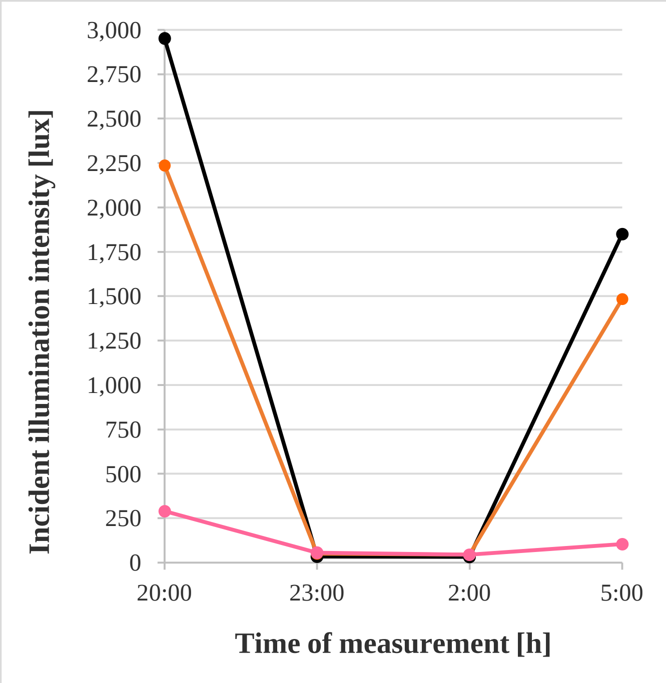

Figure 11: Incident illumination intensity in particular levels of detail in bright night conditions

Unlike the previous measurement method, where the value at each level of detail were averaged, here the levels were separated, because the plotted graphs would be distorted and should not be valuable when selecting the type of camera. Different intensities of light at different levels of detail could be caused by overexposed or underexposed scene. Both illumination intensity measurements method are capable to improve the design or the evaluation process of IVSS and final choice of cameras.

V. Conclusion

Well known methods of illumination level measurement were utilized for purposes of IVSS design in this research paper. Recent approaches and methods used were recapitulated in the first part of the paper and then the specifications of methods used for the purposes of this research were interpreted in detail. The description of measurement tools were provided in next section. Finally the main contribution is included in four sections, where the results comparison study is provided and discussed. Larger data pattern will be published in extended version of the paper. Where the other measurement approaches will be provided.

References

[1] Aldridge JJ994, CCTV Operational Requirements Manual JSDB Publication 17/94, ISBN 1 85893 335 8.W.-K. Chen, *Linear Networks and Systems* (Book style). Belmont, CA: Wadsworth, 1993, pp. 123–135.

[2] Räty, T.D., "Survey on Contemporary Remote Surveillance Systems for Public Safety," Systems, Man, and Cybernetics, Part C: Applications and Reviews, IEEE Transactions on, vol.40, no.5, pp.493, 515, Sept. 2010.E. H. Miller, "A note on reflector arrays (Periodical style—Accepted for publication)," IEEE Trans. Antennas Propagat., to be published.B. Smith, "An approach to graphs of linear forms (Unpublished work style)," unpublished.

[3] VALOUCH, Jan. Integrated Alarm Systems. In Computer Applications for Software Engineering, Disaster Recovery, and Business Continuity. The 2012 Internationa Conference on Disaster Recovery and Business Continuity, Jeju Island, Korea. Proceedings. Series: http://www.springer.com/series/7899 Communications in Computer and Information Science, Vol. 340, 2012, XVIII. Berlin: Springer Berlin Heidelberg, 2012. Chapter, p. 369 -379. ISBN 978-3-642-35267-9.J.

[4] Ashani, Z., "Architectural Considerations for Video Content Analysis in Urban Surveillance," Advanced Video and Signal Based Surveillance, 2009. AVSS '09. Sixth IEEE International Conference on, vol., no., pp.289, 289, 2-4 Sept. 2009 doi: 10.1109/AVSS.2009.112.Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, "Electron spectroscopy studies on magneto-optical media and plastic substrate interfaces(Translation Journals style)," *IEEE Transl. J. Magn.Jpn.*, vol. 2, Aug. 1987, pp. 740–741 [*Dig. 9th Annu. Conf. Magnetics* Japan, 1982, p. 301].

[5] EN 50 132-7. Alarm system - CCTV surveillance systems for use in security applications - Part 7: Application guidelines. B - 1000 Brussels: Management Centre: Avenue Marnix 17, 2011.

[6] Pavlidis, I.; Morellas, V.; Tsiamyrtzis, P.; Harp, S., "Urban surveillance systems: from the laboratory to the commercial world," Proceedings of the IEEE , vol.89, no.10, pp.1478,1497, Oct 2001

[7] HROMADA, M., LUKAS L., Conceptual Design of the Resilience Evaluation System of the Critical Infrastructure Elements and Networks in Selected Areas in Czech Republic, The twelfth annual IEEE Conference on Technologies for Homeland Security (HST '12), held 13-15 November 2012 in Greater Boston, Massachusetts. Pp. 353-358, ISBN 978-1-4673-2707-7

[8] HROMADA, M., LUKAS L., The Status and Importance of Robustness in the Process of Critical Infrastructure Resilience Evaluation, The 13th annual IEEE Conference on Technologies for Homeland Security (HST '13), held 12-14 November 2013 in Greater Boston, Massachusetts. Pp. 589-594, ISBN 978-1-4799-1533-0W.

[9] SVOBODA, Petr a ŠEVČÍK, Jiří. VBS2 Scenarios Development for PSI Purposes. In: WSEAS TRANSACTIONS ON COMPUTERS, Volume 13, 2014. ISSN: 1109-2750..

[10] SVOBODA, Petr, PADÚCHOVÁ, Alena a ŠEVČÍK, Jiří. The Use of the Virtual Battlespace 2 in TCV. In: International Journal of Education and Information Technologies, Volume 8, 2014. ISSN: 2074-1316.J. Williams, "Narrow-band analyzer (Thesis or Dissertation style)," Ph.D. dissertation, Dept. Elect. Eng., Harvard Univ., Cambridge, MA, 1993.

[11] SVOBODA, Petr a ŠEVČÍK, Jiří. The Advanced Techniques of PSI Scenarios Development in VBS2. In: Proceedings of the 16th International Conference on Automatic Control, Modelling & Simulation (ACMOS '14), Brasov, Romania, 2014. ISBN 978-960-474-383-4.J. P. Wilkinson, "Nonlinear resonant circuit devices (Patent style)," U.S. Patent 3 624 12, July 16, 1990.

[12] LUKÁŠ, L., HROMADA, M. Simulation and Modelling in Critical Infrastructure Protection, In: INTERNATIONAL JOURNAL of MATHEMATICS AND COMPUTERS IN SIMULATION, , Issue 1, Volume 5, p. 386-394, 2011, ISSN: 1998-0159, dostupnétiež z WWW: http://www.naun.org/journals/mcs/

[13] LUKÁŠ, L., HROMADA, M. Resilience as Main Part of Protection of Critical Infrastructure, In: INTERNATIONAL JOURNAL of MATHEMATICAL MODELS AND METHODS IN APPLIED SCIENCES, Issue 1, Volume 5, p. 1135-1142, 2011, ISSN: 1998-0140, dostupné tiež z WWW: http://www.naun.org/journals/m3as/

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