Quantitative and Qualitative Analyses of Landscape Views

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1 Introduction

Evaluations of landscape visual resources and estimations of the acceptable change in its character usually base on human feelings. Both expert opinions and studies, taking into consideration public preference, are frequently criticised, because of their subjective nature (SMARDON 1996). The necessity of ***objective indicators*** for the assessment of scenic values has constituted a subject of academic debate since 1970's. Unwin emphasised that landscape measurement should serve as a tool of its resources inventory and evaluation (UNWIN, 1975). Robinson argued for ***numerical and quantitative values*** that would help to reduce the subjective character of landscape assessments and would guarantee similar results, independent from the individual judgement of the observer (ROBINSON et al., 1976). The requirement of ***quantitative measurement*** of the scenery elements impact on their perception was stressed by Buhyoff and Riesemann (BUHYOFF & RIESEMANN, 1976). A coherent framework for landscape classification and valuation was proposed by Cooper and Murray (COOPER & MURRAY, 1992). They distinguished geographical units possessing similar characteristics, regarding physical attributes. This system provided the environment that might support decision making in landscape planning and management.

The aim of this paper is to present the method that base on the cooperation between an expert in the field of landscape architecture and a programmer. While, in the initial phase of the research, the expert formulates the rating of the positive and the negative aspects of the given area, the programmer tries to find the visual equivalents of these issues. They can be measured and provide tools that help in the more objective landscape evaluation, in decision making, with reference to the choice of the best scenario of its development, or allow monitoring scenery alterations in time.

The most attractive viewpoints, from which several of the valuable resources of the terrain are perceptible, are determined basing on diagrams of visibility. The more positive elements can be seen, the more beautiful this view is. Reversely, the more negative objects, the less attractive the vantage point. These places are the subjects of the researches "in situ", because of evident inexactness of the visibility diagrams (MALOY & DEAN, 2001).

For the particular view the quantitative analysis can be executed, which answer the question: ***"how much?"*** The mean area of the entity in the image can precise the characteristic parameter of the typical element. If we consider several scenarios of development, we can estimate the scale of the new objects in this view and conclude, if they fit to the environment. Here, it is worth to notice, that they can be comparable in the view, especially with respect to their size, only under the condition, that they are located in the similar distance. Therefore, the segmentation of the image into sub-images containing distance-dependent zones is necessary (OZIMEK et al., 2012).The qualitative analysis of the

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view, which answers the question ***"what kind of?"***, is far more complex. In this case ***shape factors*** can be taken into regard.

When the particular view is recognized as valuable, its character should be maintained. Therefore, all the actions consisting in introducing new elements into this environment should be aimed at preservation of its general appearance. Shape factors may serve as tools for designation of existing forms features and afterwards, by the comparison, for ascertainment, if the proposed variant of development is acceptable.

2 Material and Methods

2.1 Input Data

The eye-level view from the tourist trail, presenting a terrain intended for building development in master plan, was chosen as a subject of the research. The photographs of the current state (Fig. 2 and Fig. 3) were supplemented with the images of houses, which could be erected in the vicinity. Three different scenarios were considered:

- a housing estate, with buildings similar in size and form to the existing ones (Fig. 4 and Fig. 5);
- one big edifice (a hotel or a rest house) – alike, in relation to its shape, but dominating over the neighbourhood (Fig. 6 and Fig. 7);
- an industrial building – contrasting with its environment (Fig. 8 and Fig. 9).

The images were binarized (converted into bi-level, black and white images) in order to distinguish the building development, which constituted the subject of analysis (GONZALES & WOODS, 2002). As to compare the elements in the similar distance, the fragment of panoramic view has been chosen, which depicts the group of buildings situated along one road and the adjacent areas. In the Fig. 1 it is distinguished with a red rectangle.

Fig. 1: The 180^0 panorama with the view of the lake – the analysed fragment marked with the red rectangle

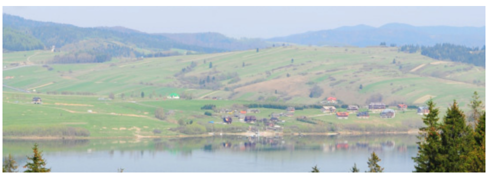

Fig. 2: The fragment of panorama showing the existing development and the terrain of the potential investments

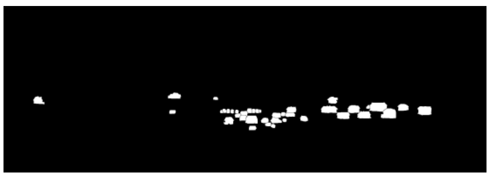

Fig. 3: The fragment of panorama showing the existing development – the bi-level image prepared for the shape factors calculation

Fig. 4: Scenario 1 – residential development similar to the existing one

Fig. 5: Scenario 1 – residential development – the bi-level image prepared for the shape factors calculation

Fig. 6: Scenario 2 – a big rest house

Fig. 7: Scenario 2 – a big rest house – the binarized image

Fig. 8: Scenario 3 – an industrial building

Fig. 9: Scenario 3 – an industrial building – the binarized image

2.2 Modelling approach

In order to determine qualitative characteristics of objects, eleven shape coefficients were taken into consideration, which, for the most part, are applied in material and medical analyses (WOJNAR et al., 2002). In a binary image, with analysed objects marked white, every object is separated from each other by, at least, one pixel. In this manner, ***isolated regions*** were obtained, that can be investigated individually. Thus, any entity in the picture has no influence on any other, and the context in which that object exists, is not considered.

To maintain order and clarity, shape factors were numbered ascending from F_1 to F_{11}.

The first two of them are ***circularity coefficients***, calculated according to formulas:

$$F_1 = \sqrt{\frac{4 \cdot A}{\pi}} F_2 = \frac{P}{\pi}$$

where A stands for an area of the object, and P - it's perimeter. F_1specifies the diameter of a circle with the same area as the object, while F_2identifies the diameter of a circle with the same perimeter as the object.

$F_3$is called ***Malinowska factor*****,** computed basing on the object's area and perimeter. It achieves higher values for elongated objects.

$$F_3 = \frac{P}{\sqrt{4 \cdot \pi \cdot A}} - 1$$

In order to calculate ***Blair-Bliss coefficient*** (F_4) we have to determine a centroid of each object. This factor is defined by the equation:

$$F_4 = \frac{A}{\sqrt{2 \cdot \pi \cdot \sum_i r_i^2}}$$

where r_i is a distance between centroid and each pixel of the object and i a number of pixel.

Danielsson coefficient (F_5) requires specification of object's contour. We assume that contour and distance are determined in Euclidean space.

$$F_5 = \frac{A^3}{(\sum_i l_i)^2}$$

l_i – stands for a minimal distance between considered pixel and the contour of the object.

Another factor, demanding high time-consuming calculations, is ***Haralickcoefficient*** (F_6), for which we use the formula:

$$F_6 = \sqrt{\frac{(\sum_i d_i)^2}{n \cdot \sum_i d_i^2 - 1}}$$

where d_i is a distance between the centroid and each pixel of the contour of the object and n defines number of pixels in the contour.

F_7 is useful in determining ***circularity*** of the object, utilizing the equation:

$$F_7 = \frac{r_{min}}{r_{max}}$$

r_{min} means minimal distance between the centroid and the contour, while r_{max} determines analogical maximal distance.

F_8 helps to measure ***irregularity*** of the object:

$$F_8 = \frac{D_{max}}{P}$$

where D_{max} is maximal dimension of the object.

F_9 is ***modified Malinowskacoefficient.*** The more circular the object, the closer this value to 1.

$$F_9 = \frac{\sqrt{4 \cdot \pi \cdot A}}{P}$$

The next one is ***Ferret coeffictient*** (aspect ratio).

$$F_{10} = \frac{D_h}{D_v}$$

where D_h is maximal horizontal dimension and D_v is maximal vertical dimension (TADEUSIEWICZ & KOROHODA, 1997).

The eleventh factor (F_{11}) is used to calculate ***the extent*** understood as the ratio of pixels in the region to pixels in the total bounding box. All the computation were performed in Matlab with Image Processing Toolbox.

The shape factors were calculated for every object and, basing on them, the arithmetic means and standard deviations of all existing elements were computed. The results obtained for the particular quantities vastly differ in range. Some of them, like the extent coefficient (F_{11}), reach fractional values, while circularity (F_1, F_2) and Danielsson factors (F_5) fluctuate from about 10 to nearly 70.

A standard deviation estimated for every shape factor is an adequate tool for determination of geometrical features of the collection of existing buildings. If the coefficient has more coherent values, it characterizes the group of objects in a better way. On the contrary, when it is diverse, we assume that it is not specific for this set of elements. In order to compare the outcomes, the results computed for standard deviation were scaled by dividing them by the arithmetical mean, calculated for a given factor.

Three scenarios of development, mentioned above, were investigated. Every new element, planned in this surrounding, was analysed, with respect to its size and shape. If its' parameters diverge from the existing elements, the conclusion is that this object is contrasting. For the new group of buildings the mean area and average shape coefficients were computed and taken into account.

3 Results

The first part of a research consists in quantitative analysis. The mean area of building was calculated basing on the bi-level image of the current development (Fig. 3) and it equals 950.69 pixels. In the first scenario (Fig. 4 and 5), for the similar housing estate that was introduced, it reached 1083. The difference in size between the existing buildings and the proposed ones came to nearly 14%. In second case (Fig. 6 and 7) the area of the edifice (6065 pixels) was more than 6 times bigger (638%) than the arithmetic mean calculated for the existing objects. In the third variant (Fig. 8 and 9), the new element, which size reached a value of 9132 pixels, was nearly 10 times bigger than the present houses (961%).

In the initial phase of the qualitative analysis, results obtained in calculations of eleven shape factors were examined, with reference to their statistics. The coefficients, for which the values were dispersed, were eliminated, whereas these with the most coherent results were regarded characteristic for the analysed group of elements. Fig. 10 shows that for the factors F_4, F_6, F_8, F_9, F_{11} the results are the most similar, so they may be recognized as typical for this set of forms. They describe an object, concerning its irregularity (F_8), compactness (F_4, F_6, F_{11}), or circularity (F_4, F_6, F_9).

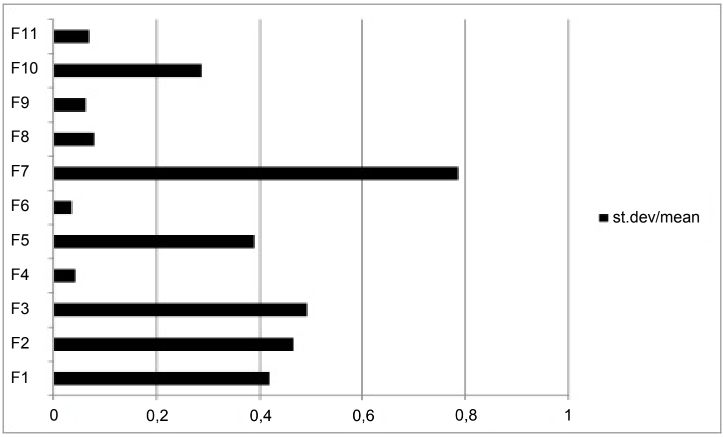

Fig. 10: A standard deviation of shape factors (numbered from 1 to 11) divided by the arithmetic mean of values obtained for the given coefficient (objects in present situation)

In the research conducted for three scenarios of development the selected shape factors of new buildings (or a mean values for the group of houses) were compared with values of the existing ones. The results of the proportional change are shown in the Fig. 11. It is worth to notice that the closer is this value to one, the smaller the difference.

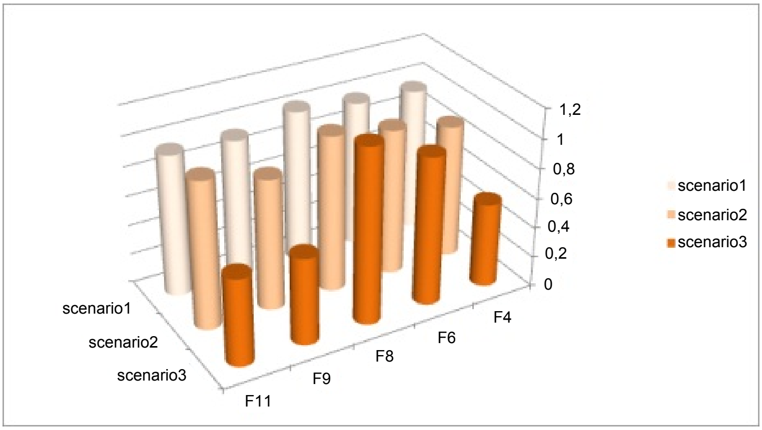

Fig. 11: A comparison between three scenarios of development and the current state

In the first situation, when the similar forms were introduced, the outcomes are in the range between 0.96 and 1.03. It is consistent with our intuition, suggesting that these houses possess features corresponding with the present ones. In the second case, the building was significantly larger than the average one, but its shape was not contrasting with the environment. These observations are reflected in change of shape coefficients, which reaches values from 0.88 to 1.05. On the contrary, in the third scenario, where the new factory visibly differs from the surrounding, the analysed shape factors clearly change (0.56 – 1.17). The biggest differences may be noticed for Blair-Bliss (F_4) and modified

Malinowska (F_9) coefficients, as well as for the extent (F_{11}), which decreases almost twice. These factors depend on the object compactness and circularity.

In every analysis of objects' geometrical parameters some imprecision appears, resulting from the fact that the elements, which are closer to the photo camera, obscure the distant ones, affecting their shape. The example of this situation is presented in Fig. 4 and 5. In order to estimate the extent of this error, another simulation was prepared. Fig. 12 and 13 shows the similar housing estate, but the layout of objects was modified, in order to separate the regions.

Fig. 12: Residential development with the change in buildings layout

Fig. 13: Residential development – the bi-level image

Surprisingly enough, in this case, the differences in shape factors (in comparison to the scenario 1 – Fig. 4 and 5) are insignificant and they vary from 0.001 (for modified Malinowska coefficient – F_9) to 0.01(for the extent – F_{11}).

4 Conclusions and Outlook

For the research the evident examples have been chosen in order to compare the outcomes with the intuitive feelings. The results, as the numerical values, are objective in their character. They may constitute a criterion, which supports the expert in the process of decision making. The set of the factors, that characterize a particular group of elements, may differ; notwithstanding, it should be born in mind that some of the coefficients are by nature more variable than the other ones.

The presented approach is applicable, first and foremost, for open views in which the analysed objects are isolated, therefore, the elements do not interfere with each other. Thus, it is more suitable for rural and suburban terrains, than for the dense built-up areas. The investigation presented in this paper applied to the estimation of building development, however, it may be extended onto the other components of a view.

The restriction of this method results from the fact that, due to the perspective distortion, only objects located in the similar distance from the camera may be compared. The shape of the elements may be affected by inexactness of their detection or, in case when it is made manually, by the human factors. Image resolution may influence the results, as well.

For the valuable viewpoint observations can be made in the regular time spans and the changes can be investigated by the comparison of the successive images.

References

Buhyoff, G. J. & Riesenmann, M. F. (1979), *Experimental manipulation of dimensionality in landscape preference judgements: a quantitative validation*. In: Leisure Sciences, 2, 221-238.

Cooper, A. & Murray, R. (1992), *A structured method of landscape assessment and countryside management*. In: Applied Geography, 12, 319-338.

Gonzales, R. C. & Woods, R. E. (2002), *Digital Image Processing.* Prentice Hall.

Malina, W. & Smiatacz, M. (2005), *Metody cyfrowego przetwarzania obrazów* (*Methods of Digital Image Processing*). Oficyna Wydawnicza EXIT.

Maloy, M. A. & Dean, D. J. (2001), *An Accuracy Assessment of Various GIS-Based Viewshed Delineation Techniques*. In: Photogrammetric Engineering & Remote Sensing, 67 (11), 1293-1298.

Ozimek, A., Łabędź, P. & Michoń, K. (2012), *Discrimination of Distance-dependent Zones in Landscape Views*. In: Buhmann, E., Ervin, S. M. & Pietsch, M. (Eds.), Peer Reviewed Proceedings of Digital Landscape Architecture 2012 at Anhalt University of Applied Science. Berlin/Offenbach, Wichmann, 464-471.

Robinson, D. G. et al. (Eds.) (1976), *Landscape evaluation – the landscape evaluation research project 1970-1975.* University of Manchester.

Smardon, R., Palmer, J., Felleman, J. et al. (1986), *Foundations for Visual Project Analysis.* New York, A Wiley-Interscience Publication.

Tadeusiewicz, R. & Korohoda, P. (1997), *Komputerowa analiza i przetwarzanie obrazów (Computer image analysis and processing).* In: Wydawnictwo Fundacji Postępu Telekomunikacji, 256-269.

Unwin, K. I. (1975), *The relationship of observer and landscape in landscape evaluation*. In: Transactions of the Institute of British Geographers, 66, 130-133.

Wojnar, L., Kurzydłowski, K. J. & Szala, J. (2002), *Praktykaanalizyobrazu (Practice of Image Analysis).* Polskie Towarzystwo Stereologiczne, Kraków.