GIS ANALYSIS IN CULTURAL LANDSCAPE PROTECTION. EXAMPLE FROM CZECH REPUBLIC

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ABSTRACT
UNESCO considers cultural landscapes a part of the world heritage and recognizes three main categories: designed, organically evolved and associative. Protection of designed cultural landscape gained in recent years much attention in the Czech Republic, proved by the establishment of 24 protected areas of cultural landscape. In order to keep these areas, development of specific tools is necessary. Paper describes methods of impact assessment of cultural landscape in which GIS plays a crucial role. Part of the method is a visual analysis using viewshed tool and digital surface model considering the distance and mass of assessed object. The – this technique deals with the implementation of distance and angle size of an object in viewer's eye as a function of viewshed. The big object in distance has the same angle size as a relatively small object which is near. The second part deals with so called geo-verified photomontage, which is a technique securing proper photomontage of the proposed object. The technique is based on the proper placement of the proposed object as well as the well-positioned observation point from which the photograph for visualization is taken. These first tool is necessary to scope of assessment, the second technique is necessary to present the findings. Both techniques were tested in Lednice-Valtice Area, an UNESCO heritage site in 2015. The method which uses both techniques has been approved as a standard method by Ministry of Culture of Czech Republic.

Keywords: *Lednice-Valtice Area, GIS, viewshed, simulation, cultural heritage*

INTRODUCTION

For impact assessment in landscape conservation zones the perception of the landscape is essential. A dominant sense in the perception of the landscape considered by most authors is vision [1–3]. Visible landscape features are described as landscape physiognomy [4–6] or visual landscape [7–9] Research on visual characteristics of the landscape combines the spatial properties of the landscape e.g. topography and objects on the surface as well as their visual characteristics. The landscape visual and spatial properties differ from one another [4, 6, 10].
Approaches to the visual evaluation of the landscape can be divided into:

- Technological: using GIS to analyze the area based on terrain modeling and viewshed analysis [11–14]
- Photographic and artistic: the use of panoramic photos, and differential methods of identifying landscape painting [15, 16] and character interpretation of landscape painting [17–19]
- Socio-psychological: using qualitative sociological survey (interviews) and quantitative research (questionnaire) [20]
- Combination of the above mentioned approaches

Landscape perception is always burdened with a certain degree of subjectivity. The aim is to develop a procedure that does not replace the subjective assessment, but rather creates the background able to evaluate the proposal objectively.

METHODS

Our approach is aimed at assessment of new proposals in landscape conservation areas and contains methods for of technical and non-technical character. The purpose of this article is to inform about the technical procedures, therefore non-technical procedures are omitted. Principles applied in the proposed procedure stems from environmental impact assessment (EIA) since its universal application. The method uses GIS in the as an initial step for to scope the extent in which the proposal will be visible and as a tool for geo-located 3D visualization of proposal.

Determination of visual impact of a proposal

Demarcation of the territory using tools as viewshed, allows to specify the visibility of the proposed building site and determines areas, from where the building is completely or partly visible. The method uses points which are located on the surface of proposed building and helps determine which part of building is visible and from where (Fig. 1). The process follows these steps:

1. Preparation of digital surface model (in the Czech Republic it is available online as a grid with resolution 2x2 m).
2. Georeferencing of proposal. Any proposal that should be objectively assessable in GIS must be georeferenced. That means they must be placed in a coordinate system conforming to a digital terrain model on which the visibility is calculated.
3. Insert boundary points of proposed building and assign them to the building height. Height of the points must meet the design documentation project.
4. Calculation of the visibility of proposal using tools Viewshed, Observer points or Visibility.
5. Calculation of Above Ground Level (AGL) grid. Above ground level grid allows to define area, where the proposal will be visible from certain height above ground.
6. Demarcation of the territory on topographic map and verification via field research.

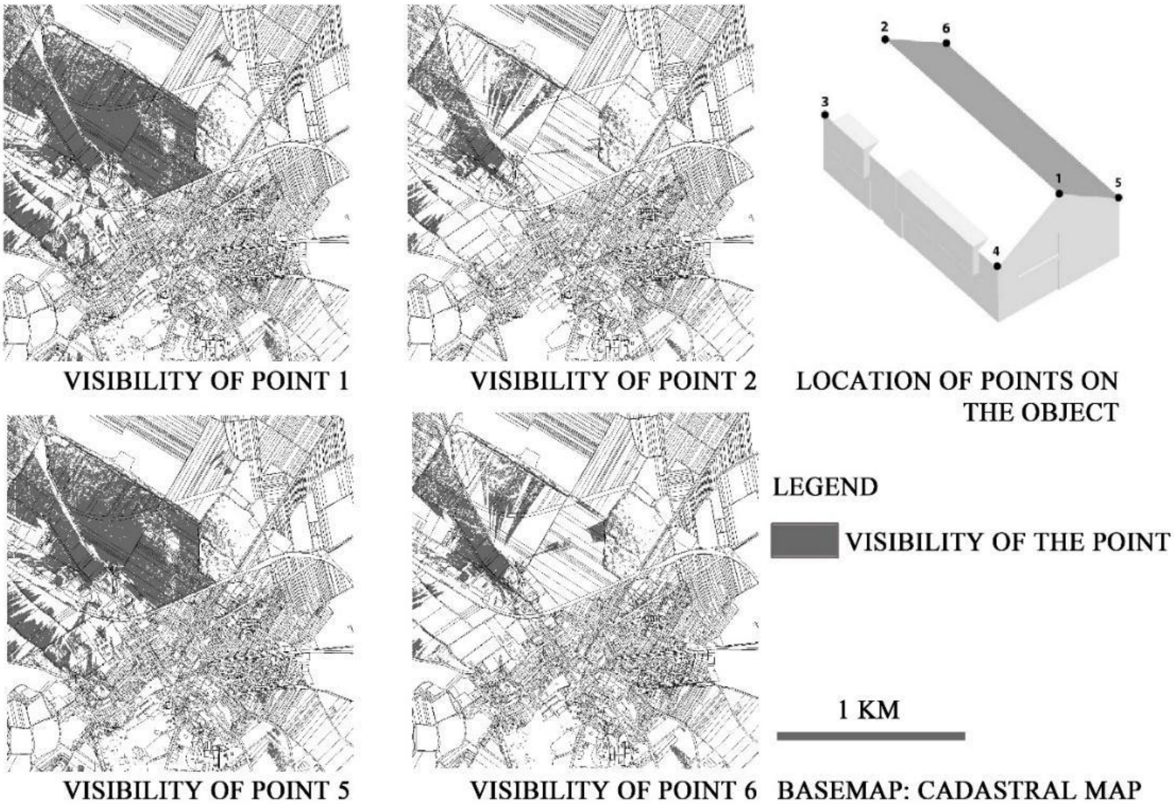


Fig. 1. Determination of visibility of a proposal and its parts. Each map represents visibility of different part of an object.

Determination of the relative visibility of a proposal

Relative visibility analysis is based on calculating the visibility of an object depending on its size. The hypothesis is based on the assumption that a small object in the foreground occupies the same visual angle as a large object in the background (Fig. 2). The size of the object as perceived by observer depends on the visual angle. Visual angle is an angle that viewed object subtends at the observers eye.

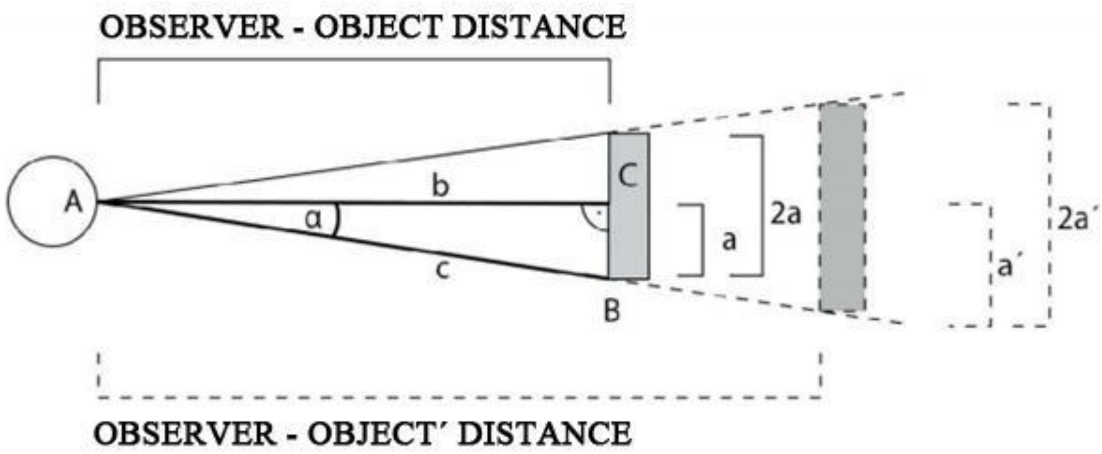


Fig. 2. Diagram shows dependency between size of the object, distance and visual angle. Smaller object in foreground subtends same visual angle as the bigger object in background

Threshold ability to recognize an object in the background is one minute. Ogburn [14] derives these values from theory of visual structures [21] in the landscape when examining the visibility of archaeological sites in the prehistoric. It is based on the assumption that the object is clearly discerned in the distance, which occupies less than 1° field of view, while the threshold is 3 minutes in the field of view of the observer.
The calculation procedure is performed by following these steps.

1. Defining the width and height of the proposed project.

2. Use above mention data and digital surface model to calculate Viewshed binary values – 0 and 1. Value zero stands for non-visible area, value 1 stands for visible area.

3. Calculation of distance grid from the proposal in the extent of binary viewshed from previous step.
4. Relation between the visual angle, the distance from the observer and the size (width or height) of an object can be written as:

$$tg\ \alpha = \frac{a}{b}$$

in which "a" is half the width of the building and "b" of the observer distance from the object, ie after adjustment:

$$tg\ \alpha = \frac{2a}{b}$$

Calculation is performed by using Map Algebra expression using the size of the object (2a) and distance grid calculated in the 3rd step.

5. The resulting grid is then multiplied by the grid values of Binary Viewshed where – in which visible places are multiplied by 1 and place the hidden value with zero. Resulting raster contains value of potential visual angle of the object and determines the visible extent of a proposal.

Verified 3D visualization

Visualization techniques are an established tool to show a proposed state of landscape [22], [20][23], [24], [2]. For these purposes I used the concept of landscape visualization [9], environmental

visualization [7, p. 29], or geovisualisation [25]. The term landscape visualization is used for computer-generated depictions of the landscape in perspective [9]. Validity is the extent to which a concept, conclusion or measurement is well-founded and corresponds accurately to the real world. Which kind of visualization may have higher degree of validity, is the question many authors have dealt with and has been documented in several case studies e.g. [3] [9] [26] [27]. The authors had confirmed that realistic rendering makes a proposal more comprehensible to the public.
The validity of our method is guaranteed by defining the rules concerning site selection, preparation and georeferencing of the proposals model, rendering scenes and pasting into photograph.

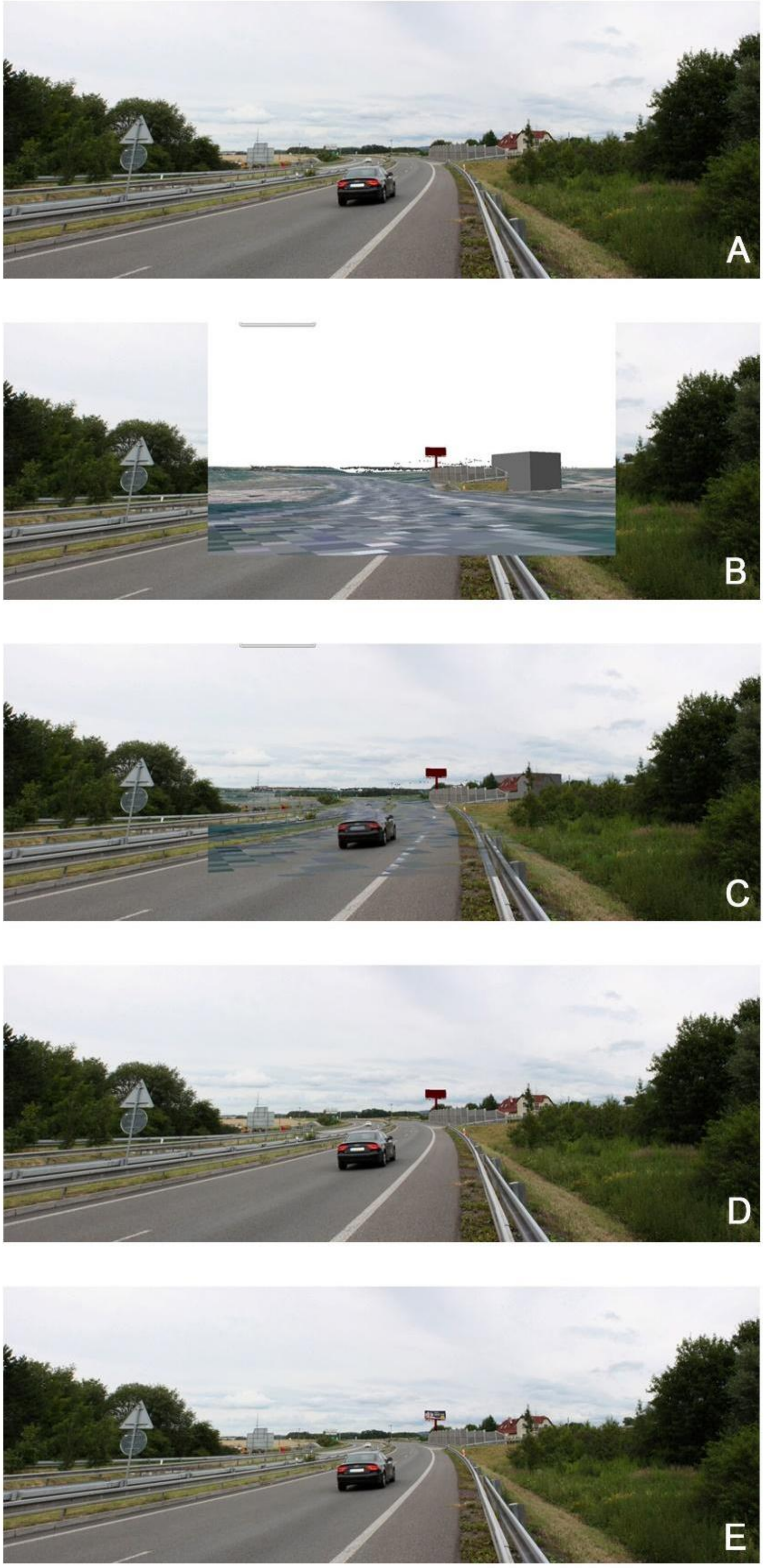
1. Site selection for photography capture.
   - Photographs must capture the subject in context with its surroundings
   - Photographs must be captured at good visibility
   - Picture shall be captured to provide detail about 40°
   - Camera during shooting should be between 150 cm and 180 cm above the surface
   - Location from which the photography was taken must be accurately determined (at least using GPS)
2. Preparation of the model and georeferencing of the model.
   - The model is created in a 3D representation (level LOD2 or LOD3) based on the project documentation
   - Object has to be textured on the basis of the materials specified by the design documentation
   - Preparation of digital model of the terrain and surface
   - Displaying digital landscape model in the graphics software that enables 3D viewing and location of the object in the coordinate network
3. Rendering the scene and fitting into the picture (Fig. 3).
   - The location of the object in the landscape model, camera settings and export scene must match the site of taking photos
   - Viewing angle must correspond visual angle
   - Focal length for export must match the focal length of the photograph
   - Export into graphics
   - Overlay exported graphics with a photograph. An important step is the correct classification of the proposal within photograph.

Software and essential data

Essential dataset is the digital surface model, because of its better validity for visual analysis [13]. Digital surface models can be used in TIN or grid representation. The method used DMP 1G provided by Czech Office for Surveying, Mapping and Cadastre. Digital surface model represents a display area including buildings and vegetation covered with an accuracy of 0.4 to 0.7 and its grid representation must be accessible to the general public. The major advantage of this model is its availability for the in entire Czech Republic and can be used for analysis be used for assessment of proposal on at various places in Czech Republic.

GIS analysis were performed in ArcGIS 10.3.1 with 3D Analyst and Spatial analyst extension. Using of other SW applications is possible (GRASS, White BOX GIS).

For modelling of the digital model of the proposal was used SW Blender version 2.61 with render engine Blender Cycles. For editing and image manipulation was used SW GIMP 2.7.



Step A. The picture is captured from relevant location. The viewing angle is at least 40°.

Step B. The rendered scene is overlayed on photography.
The scene is made from digital surface model and building models with level of detail LOD1 (buil-dings) and LOD3 (proposal).

Step C. Change of transparency helps to adjust rendered scene into photography.

Step D. After adjus-tment is the object cutted out from the image and the rest of image is deleted.

Step E. Adding textu-re to an object.

Fig. 3. Process of adjustment rendered scene into photography.

CONCLUSION

Presented methods showed technical part of standard process of impact assessment in cultural landscape zones for local authorities. It is a part of the method that has been approved as a standard method by Ministry of Culture of Czech Republic. Steps of the process can be applied on different datasets, but the validity of the method depends on accuracy and homogeneity of the digital surface model, that could vary throughout the Czech Republic. Presented analysis doesn't substitute field survey on site. Nonetheless is it a helpful tool for presentation of the potential impacts on landscape for the public as well.

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