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PANORAMIC VIDEOGRAPHY AS A POTENTIAL TOOL FOR ENHANCEMENT OF LAND INTENSITY FACTORS

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Summary

The article explores the potential of using panoramic videography for the spatial engineering and spatial management of landscape. The concept of panoramic photography, as a basis for panoramic videography, has been widely used for visualisation of cultural heritage sites and documentation of various sites. Panoramas are widely used, for example, by Google in StreetView to present not only the cityscapes, but recently also rural landscapes. Panoramic videography is a process of creating panoramic (360-degree) video, which represents the dynamic environment. The land intensity factors (WIT – in Polish: "współczynniki intensywności terenu") introduced by Litwin is a method for evaluation of the landscape where different functions can be specified: agricultural, non-agricultural and recreational. Although this method can be used in different terrains, this article proposes to use panoramic video camera for the enhancement of the recreation function of WIT.

The process of creating panoramic videography is explained in this article as it was tested and explored in the United Kingdom (in Launceston) and Poland (the district of Czarny Dunajec). It is based on gathering imagery not from airplanes but from a mobile setup that traverses through streets. What is more, the combination of vector and raster modelling of terrain in a visual and interactive environment has a potential to become a powerful tool for enhancement of land intensity factors. The administrative borders are one of the drawbacks for a determination of WIT and comparing them to terrain values. This article proposes the application of a path-based approach to visualize changes in land value and recreation function thanks to data collected from panoramic videography and information input to database. Annotations and measurements (panoramic photogrammetry) gathered from geo-referenced video provides a potential not only for determining WIT factors, but also for regional planning.

Keywords

landscape • landscape inventory • regional planning • spatial engineering • development of rural areas • 3D visualisation • panoramic videography • panoramic photography • photogrammetry • LIS • GIS

1. Introduction

The discussion about the surrounding landscape is becoming more evident in our lives. A number of studies [Gulati et al. 2007, Ritters et al. 1995] analyse landscape from maps, aerial images or satellite imagery, but there are few scholars [Brook and Dunn 2011] who take a street level view approach to evaluate and define the landscape in a specific region. For instance, let's take, the road between Kraków and Zakopane called "Zakopianka". When tourists are close to Zakopane, they see a lot of billboards and illegal adverting constructions instead of the Tatra Mountains. Figure 1 illustrates such a situation in Nowy Targ. The billboards cannot be seen from aerial imagery, they can only be noticed from the street level view as for example through the application of Google StreetView.

Photo by Kwiatek 2013

Fig. 1. A street level view in Nowy Targ. The billboards are obscuring the view to the Tatra Mountains

Between 2011 and 2013, Google has visualised this road and most main roads in Poland using panoramic photography [Anguelow and Dulong 2013], however such a method cannot be used for the terrain evaluation for a number of purposes:

- images stored on Google servers and the update is not frequent,
- there is no possibility to add information (annotations) to Google StreetView imagery and create databases based on such surrounding imagery.

The method proposed in this article is to apply panoramic geo-referenced videography in order to gather, in a continuous and interactive way, information about objects to be removed or objects to be added to the landscape. This paper presents the application of Horus software developed by Horus View and Explore B.V. from the Netherlands. This process has a potential to enhance the recreation function of WIT, introduced by Litwin [1997].

The following sections introduce land intensity factors and the concept of panoramic videography which help to notice changes in a particular region.

2. Aims and objectives

Bojarski [1984] who defines the classification of models (according to the target) introduces three different types of models that could be analysed:

- documentary models which illustrates chosen features of the object,
- cognitive and predictive models which show the rules of object function and see the future states,
- decisional and exploratory models are good for testing the behaviour of objects.

This article attempts to present panoramic videography as a method that could include most of the above mentioned characteristics of Bojarski's model:

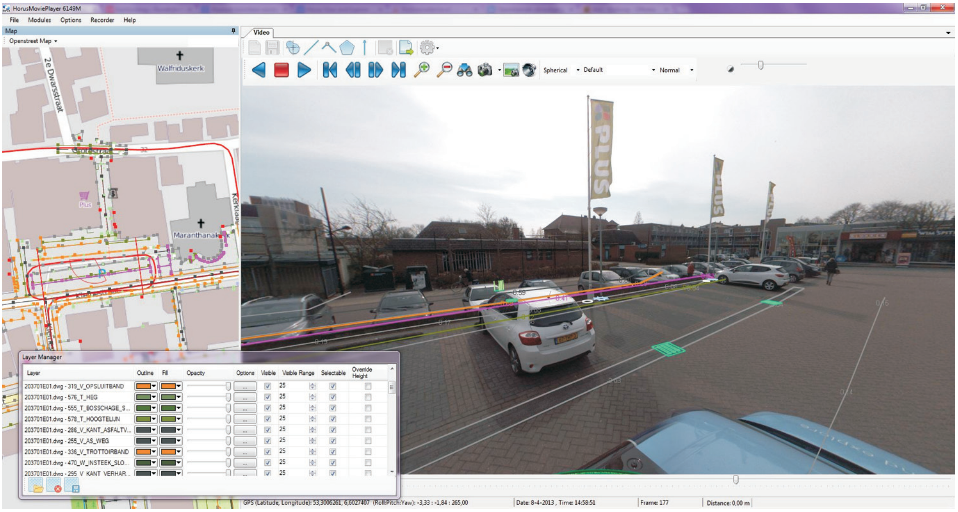
- documentary – photography shows reality,
- cognitive and predictive – when connected to database,
- decisional and exploratory – change of point of view allow to see the same object from multiple perspectives and decide whether it fits to landscape.

Bojarski's classification indicates that photography connected with a database has a potential to be a powerful predictive tool for landscape evaluation and spatial planning. Land Information System (LIS) and Geographical Information System (GIS) are computer systems of gathering, processing and popularizing of information located in space. It is not essential to have photography linked with database in LIS, however georeferenced imagery helps to visualise the landscape and can be used by professionals such as design companies, development agencies, units of government administration, research institutions or scientific research centres. Spatial information contains data about location, spatial features, coordinates and the relation between objects that can be related to the surface of Earth [Burrough 1986, Gaździcki 1990].

Databases are visually shown in the form of spreadsheets or information connected to maps. However, Horus software allows connecting such information to a particular place, not only with photographs but with still and video panoramas which are presented in an interactive form in the window as indicated in Figure 2.

The method for displaying panoramic photographs in GIS systems (e.g. in ArcGIS) is not new and was explored by GIS specialists [Clifford et al. 2010] and Verbree when describing panoramic imagery of Cyclomedia [Verbree et al. 2004] but panoramic videography has not been widely used in GIS or LIS systems so far. Panoramic video may be used not only for describing landscape but they also allow the operator to measure distances and areas in the terrain.

There are two popular methods of modelling and describing the landscape. Traditional methods of using aerial imagery to present changes in geographical features of the terrain (a number of buildings, the length of river per km sq.), but they do not illustrate street level information such as new asphalt on the road, new elevations of building, investments of citizens into their properties, cultural heritage locations, new enterprises and initiatives. These factors, visible from street level, influence the land intensity factors. When gathered every year, on the basis of panoramic videography, they provide information on whether the specified village or region has increasing or decreasing richness [Litwin 2004].



Source: www.horus.nu © Horus View and Explore B.V., The Netherlands

Fig. 2. A screenshot from HorusMoviePlayer where panoramic videography is merged with GIS data. Permission to reproduce this image has been granted by Dirk Aalbers

2.1. Land intensity factors WIT

WIT in landscape was defined by Litwin [1997] and illustrate diverse landscapes for a specific region. They present the differences between villages in one region, in three primary functions of landscape: agricultural, non-agricultural and recreational. Different functions of landscape can complete one another or combine with to create a more aesthetic space. On the practical side, the factor that defines the terrain is the value of the land. The value of land is different and is dependant on many factors. Some of them are e.g. the distance to the larger town or city, the shape of land, development of infrastructure, soil quality classes, land topography. Litwin compared the theoretical value of landscape represented by WIT with the practical value, taken from a database of market real estate values. Litwin [1997] presented such a comparison for the Kotlina Mszanska and the Gmina Olsztyn near Czestochowa [Litwin 2004]. The above-mentioned publications constitute attempts to order the researched region. In order to gather theoretical value of the landscape Litwin [1997, 2004] created 29 parameters of landscape that helped to calculate WIT. The data were collected from [Litwin 2004] The District Office, topographical map @ 1 : 10000 but none of them were gathered from a site visit or street view level.

From the list of 29 parameters, there are only a few features that can be accessed visually on the site or from street view imagery (building material, building age, type of development). Most of the features do not relate to the recreation function of the landscape. For this article, a few new parameters (Table 1) are proposed which could enhance the calculation of WIT, especially WIT_3 that refers to the recreational function.

Table 1. The proposed factors with their new numbers

30	Cultural heritage site
31	Tourist attraction
32	Cycle path
33	Prosperity of citizens
34	Redevelopment of houses
35	Shops and types of shops
36	Trees and types of trees
37	Condition of roads
38	Vegetation

Most of these new features are not updated on maps regularly. They are visually visible from street level imagery but not from aerial imagery. They definitely attract potential tourists and those who are looking for recreation in the particular area.

According to Litwin [1997] WIT_3 that relates to recreation is calculated:

$$WIT_a = a_1\, z_1\, x_1 + a_2\, z_2\, x_2 + a_n\, z_n\, x_n \tag{1}$$

where: x_1 ... x_n – set of normalized features of the areas, $a_1 \ldots a_n$ – set of weight "advantages" determined on the basis of experts test, $z_1 \ldots z_n$ – factors of "importance" which determine the meaning of particular features.

2.2. WIT3 factor

The calculated WIT_3 allows seeing the potential of a particular area and opportunities in the development for tourist. As it was noticed by Litwin [2004], the calculated potential related to the administrative borders of the village are generalised. One part of the village might have different WIT_3 than the other parts. This is why the authors propose to map the WIT_3 factor through traversing paths and roads in the village, following the way the panoramic video camera records the landscape. Panoramic videography enables seeing new parameters individually (30–38) individually and to notice the attractiveness of the terrain. Figure 3 presents the panoramic videography recorded in the district of Czarny Dunajec where the user can choose different directions of viewing.

Photo by Kwiatek 2013

Fig. 3. Rural areas visualised using panoramic videography in the district of Czarny Dunajec. Spherical 3D viewer developed by Point Grey Research helps to choose different views

3. Panoramic videography

Panoramic videography has its roots in panoramic photography. Panoramas improved the visualisation of interiors of the world and they became a part of our lives [Huang et al. 2008]. However, the advances in computer technology, larger broadband and the improvements in digital camera technology have led to the creation of panoramic video (360-degree video) which is a sequence of 360-degree images displayed as a film (for example 30 panoramas per second). Table 2 presents the comparison between panoramic photography and panoramic videography.

Table 3. The comparison between panoramic photography and panoramic videography

Panoramic photography	Panoramic videography
Still imagery	Video (15–30 frames – panoramas per second)
Represents static scene	Represents dynamic scene
Basis for virtual tours, where only selected fragments of land are visualised	When traversed, the whole environment is recorded without breaks
Used in Google Street View	Not yet implemented in GIS, immersive cinematography

3.1. Panoramic video cameras

Panoramic videography is becoming widely accessible through the use of spherical and panoramic video cameras: Ladybug [Point Grey Research Inc. 2008], Dodeca [Immersive Media 2009] or a set of GoPro cameras. This research paper examines the use of Ladybug cameras (Figure 4) within a landscape research. Other applications (immersive cinematography, cultural heritage, game industry) of the spherical video cameras were described by the author [Kwiatek 2013, 2011, 2009]. Table 3 represents some details from two spherical video cameras which the author explored at the Plymouth University in the UK.

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Fig. 4. Spherical video cameras – Ladybug© 2 and Ladybug© 3

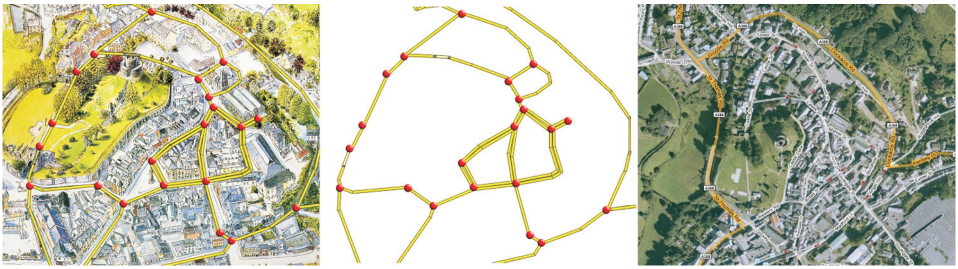
Table 3. The comparison between two spherical video cameras

	Ladybug© 2	Ladybug© 3
Max resolution [px]	3500 x 1750	5400 x 2700
Max frame rate [fps]	30	16
Data transfer [GB · min^{-1}]	2	3
Weight [kg]	1.19	2.41

Production of panoramic videography (360-degree video) involves the process of stitching together separate videos (recorded at the same time – pointing in different directions and synchronised) in order to achieve a panoramic footage [Huang et al. 2008]. Figure 4 presents high-end cameras that enable recording 360-degree video. These cameras are available commercially and generate spherical video without additional post-processing. However, there are also other devices that, instead of creating spherical video, produce separate videos that need to be stitched and additional post processing is necessary. The quality of video recordings produced by such rigs are suitable for publication on the Internet and for display in immersive environments, but the process of presenting results is more time consuming. Panoramic videography generated by Ladybug cameras can be calibrated and merged with databases. Six lenses are in the same position all the time and their parameters can be estimated, whereas in the case of a rig consisting of multiple cameras, individual parameters need to be estimated and calibrated every time before starting recording.

3.2. Traversing with panoramic video camera

The system of recording video panoramas was developed in Plymouth, UK by the author. However, it was not necessary to link 360-degree video with database. In order to collect information necessary for WIT_1, WIT_2 and WIT_3 from the terrain of one village, the camera operator has to drive through all roads and public paths. Figure 5 indicates a structure of the town of Launceston where recordings of panoramic videography (yellow lines) were conducted between crossings (red dots). The concept that is presented in this paper is to calculate WIT factors along paths and streets.



Source: Kwiatek 2013

Fig. 5. Streets and public paths in Launceston where panoramic videography was recorded. Permission to reproduce the image has been granted by Charles Causley Trust

The recording of panoramic videography takes about one day per village. The operator of Horus software can add new information and attach them to particular objects visible in the panoramic videography. For instance, when a billboard is recorded, the software operator can assign it an icon with a small description stating whether it should be removed or left as it is. Horus is the solution for this application. 360-degree video indicates a particular panoramic view from every position on that path. The user can look around, as in Google Street View see the dynamics of the surrounding and also conduct measurements without leaving the office.

3.3. 3D models and panoramic videography

It is essential to mention that the spherical video camera is moving through a space and records 360-degree video. The arrows (annotations) on the map are changing their position (Figure 6). Annotations such as information about the address, road condition, tree condition can be interactively added to the application.

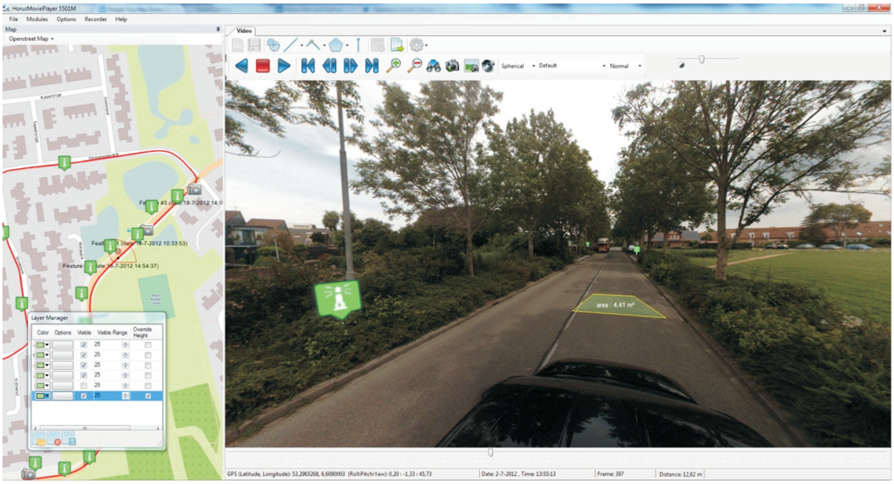
Source: www.horus.nu © Horus View and Explore B.V., The Netherlands

Fig. 6. The drive through a road with multiple annotations. These arrows (icons) contain information which can be accessed interactively and are changing their position on the displayed geo-referenced panoramic videography. Permission to reproduce this image has been granted by Dirk Aalbers

3.4. Mapping the terrain using panoramic videography

Figure 7 indicate the process of mapping and measuring a terrain from panoramic videography once the 360-degree video is calibrated. The user can map planes, add points to the base map which are automatically added to a map where their coordinates are stored in a database. Every object can be assigned an attribute and new attributes can be added to all visible elements in panoramic videography.

The following section focuses on experiments in achieving a mobile setup for panoramic videography recording system. The Ladybug cameras from the Canadian company Point Grey Research are designed to be mainly used in an office. However, the author used a mobility scooter for the purposes of gathering WIT in the UK. In this way, landscape researchers will have a tool for adding visual information not only to the cityscapes but also in rural areas. The new methods and software presented allows the computer operator to merge vector and raster data, in order to mark objects that need to be removed or added to the landscape. This editing is necessary, in order to improve *terrain intensity factors* that relates to different functions of the land.

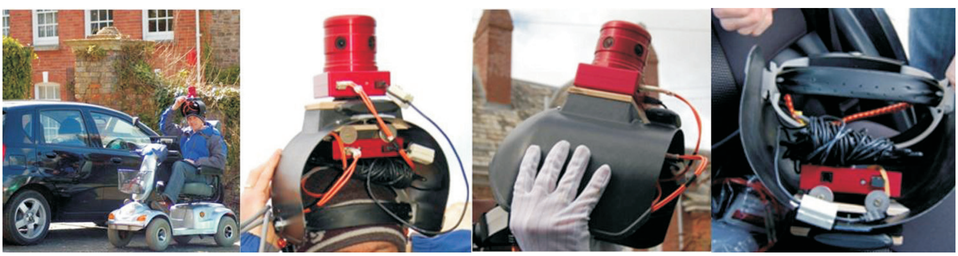


Source: www.horus.nu © Horus View and Explore B.V., The Netherlands

Fig. 7. 3D mapping of the rural area where vector data and measurements are added to panoramic videography and also to the map (left). Permission to reproduce this image has been granted by Dirk Aalbers

4. Path-based approach to land intensity factors

The author created a mobile device that allowed movement from one location to another with the camera attached on the operator's head. The mobility scooter was used for recording rural areas in the United Kingdom. The small town of Launceston, located in the south-west of England, was visualised. Figure 8 illustrates the process of mounting Ladybug camera on the head of the operator. This setup was ideal for the sites where the mobility scooter could be driven. The next model of the setup described in Kwiatek [2013], has a pole in the back of the mobility scooter for more stable recordings. However, such a system is not ideal for recording long distances and the author installed Ladybug camera at the top of the car (Figure 9).



Photos by Kwiatek 2013

Fig. 8. The process of mounting Ladybug spherical video camera on the head of the operator. The camera needs a heavy battery and a laptop to record 360-degree video

Photo by Kwiatek 2013

Fig. 9. Ladybug© 3 camera installed at the top of the car before recording the district of Czarny Dunajec in Poland

4.1. Mobile setup for panoramic videography

The setup for the video camera consisted of the following elements:

- a mobility scooter that could drive on public roads,
- Ladybug 2 spherical video camera,
- a welding helmet with a prepared attachment for the camera,
- a compressor for Ladybug which attaches to the welding helmet,
- Firewire800 cable,
- ExpressCard with Firewire800 slots,
- a laptop (equipped with RAID0 hard drive configuration; RAID0 increase the speed of transferring data (1GB $\cdot$ min^{-1}) coming from the camera),
- a 12V battery and power cable (to power the spherical video camera),
- a cover for the camera and the laptop (the setup was not water-proof),
- software: Ladybug®CapPro from Point Grey Research,
- two 1TB additional hard drives (for back-up of recordings),
- a battery charger for the mobility scooter (for charging batteries at night),
- a battery charger for 12V battery,
- a battery charger for the laptop,

The setup for the video camera mounted on the top of a car consisted of the following additional elements:

- a hatchback car,
- a roof rack,
- Firewire 800 cable,
- ExpressCard,
- GPS receiver.

The above mentioned setups are a low and high cost method of recording panoramic videography in the town and that can also be used in rural areas. The recordings of the city of Launceston were performed on a mobile platform and the panoramic film is available on-line at: www.360stories.net/causley. The recordings from Kraków are available on-line at: www.360stories.net/krakow-360video. This paper presented only two of the approaches to recording video panoramas through paths and presented the idea of gathering data (e.g. land intensity factors) from panoramic videography. The authors hope that the combination of these two methods has a potential to be examined in the rural areas of Poland.

5. Conclusion

The idea presented in this paper explores the potential of using panoramic videography as a tool for the evaluation of landscape. This tool when connected to a database can be an important method for evaluation of landscape changes and the design of the landscape. This visual application with its easiness of drawing and mapping can be used not only by professionals (landscape architects, town planners, land surveyors, photogrammetrists) but also by individual citizens. Panoramic videography is mainly used in immersive filming for planetariums and dome screens. It has a potential to be used as a monitoring tool for villages (for determining land intensity factors), cities (cultural parks, e.g. Park Kulturowy Stare Miasto in Kraków), roads ("Zakopianka" near Zakopane) and also individual buildings (hospitals, schools, railway stations where the information system need to be improved).

The authors hope that the new method of visualisation will be applied by architects of landscape. It is clear from this paper that the visual aspect of estimation of land intensity factors is helpful in determining features of landscape. The interactivity and the surrounding aspects of geo-referenced video connected with databases provide a unique tool for landscape arrangement and sensible management and environment protection.

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