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ROAD LANDSCAPE MODELLING

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Abstract

Road landscapes can be considered important resources for place development. They create impression about the infrastructure of places and transport, which is an important aspect of attracting investment and tourism development. Yet this field of landscape planning and design is hardly studied and needs more attention in Latvia. Institutions at different planning levels and from several fields of expertise are involved in road landscape development. In order to achieve successful cooperation among all the parties involved, it is necessary to reflect the information about road landscape development in the way that it can be easily perceived and understood. Studies in landscape perception prove that people perceive visual information about landscape design and planning better than textual information and regular maps. The purpose of the paper is to introduce with a method of three dimensional (3D) road landscape modelling, developed by authors as a tool for road landscape design aesthetic evaluation, which can be used to demonstrate design variants to wider public and stakeholders. We demonstrate what kind of data are necessary for road landscape modelling, how they are obtained and processed, why certain modelling programs are chosen. The methodology, problems, which occurred during the modelling, and the chosen solutions are described. Results show that chosen methodology is appropriate for large scale projects. The experience gained from the project helps to evaluate the suitability of certain computer programs for road landscape planning and design.

Key words: 3D modelling, landscape design, LiDAR data, Sketchup, Lumion, animation.

Introduction

Road landscape supports safe functioning of road infrastructure, enhances the road environment for road users, creates the first impression about the place and blends the road into the surrounding landscape. According to the Latvian Landscape Policy Guidelines, road landscapes are important resources for place development. View from the road creates an impression about the infrastructure of the place and transport, which is an important aspect of attracting investment and developing tourism (Ainavu politikas..., 2013). The research on the road landscapes in Latvia, shows a decrease in the visual quality of landscape and loss of the identity of the place, disappearance of distant and open views, historical and cultural values (Vugule, 2013). Issues regarding road landscape need more attention and should be discussed at all planning levels.

Territories within the road landscape corridor, which is 2 km wide (Slēde & Vikmanis, 1980), belong to certain owners, but landscapes are viewed and used by many local and international users. Landscape planning involves institutions at different planning levels. The Ministry of Transport operates at a national level with the effective maintenance, security and development policy of the Latvian road network. Planning regions develop long-term and medium-term development planning documents – territorial plans and development. Municipalities and land owners are responsible for activities at a local level.

The efficiency of public participation in landscape planning and design process is often negatively affected by various economic and social issues as well as by cognitive limitations. Human landscape perception is based on a complex aesthetic functional context. Only through the intellectual processing of what has been seen, does the detailed visual information of a landscape turn into what we call ‘landscape’. In this interaction, the aesthetic product ‘landscape’ mainly results from the driving forces ‘education’, ‘experience’ and ‘enjoying observation’ (Werner *et al.*, 2005). Successful cooperation is possible among all stakeholders in road landscape development if the information on road landscape issues is presented to various institutions involved and the public in such a way that it can be easily perceived and understood.

Landscape architects, architects, planners, engineers are trained to understand and follow 2D project plans, while other people might have difficulty to read and understand how future landscape and its elements – a terrain, roads, buildings, trees, water elements, etc., will look like. For many years landscape architects and planners have been creating beautiful perspective drawings and paintings. Considerable studies in landscape perception highlight the need to use visualisations in landscape design and planning to improve the understanding of project and landscape changes (Daniel & Boster, 1976; Hanzl, 2007; Hassan, Hansen, & Nordh, 2014; Tress & Tress, 2003). Studies also confirmed that people perceive visual information about landscape design and planning in 3D visualisations better than text and regular maps. Three dimensional visualizations are especially beneficial for greater collaboration involving those untrained in community decision making (Bishop, 2005; Hassan, Hansen, & Nordh, 2014; Kwartler, 2005).

As there has been a significant development in the field of computer graphics over the last two decades, the ability to link CAD (Computer Aided

Design), GIS (Geographical Information System) and landscape visualisation software has dramatically extended the possibilities of digitally representing landscapes and environment (Lovett *et al.,* 2015; Paar, 2006). Now the main types of 3D outputs are still rendered images, panoramas from defined viewpoints, animations (showing fly – over or walk – through of the site) and real time models, by looking at which the user has the ability to freely navigate a landscape (Bishop & Lange, 2005; Lovett *et al.*, 2015; Mengots, 2016). Geodesign is often used for planning purposes as it includes project analysis, design specification, stakeholder participation, design creation, simulation, and evaluation. Perception-based studies of road project and road planning for scenic environment have been carried out by using ArcGIS software (Jiang, Kang, & Schroth, 2015; Yangyang & Yuning, 2017). ArcGIS has developed 3D visualization possibilities, but our assumption is that GIS based modelling is more appropriate for analysis by experts and does not look realistic enough for landscape evaluation by non-experts. Animation has been chosen as a visual simulation for the research object as it gives a more complete picture for consideration of the changes in environment and landscape (Lange & Bishop, 2005). Moreover, road landscapes are mostly seen in motion from a moving vehicle and speed is an important factor in road landscape perception (Bell, 1997). Landscapes are very complex and detailed structures, which often cover very large areas and it is an extremely challenging task for visualisation. The reduction of landscape details brings certain sterility in virtual landscapes (Lange & Bishop, 2005). This raises a question – what is understood by good enough visualisation for effective planning? Sheppard (2005) suggested guidance on the quality of visualisations based on six principles at the pre-construction stage. These principles are: accuracy, representativeness, visual clarity, interest, legitimacy, and access to visual information. Sheppard (2005) also suggests developing standards for preparation of visualisations and presentation of future landscape. Rekittke & Paar (2010) conclude that there is a need for realistic and authentic setting, and real activities by people or animals must be included in visualisation. Without them, these images will represent fantasy world.

The purpose of the paper is to introduce the method of three – dimensional (3D) road landscape modelling, developed by authors as a tool for the aesthetic evaluation of road landscape design, which can be used to demonstrate design variants to wider audience and stakeholders. The project consists of data collection using laser-based mobile mapping technologies (LiDAR), data processing, development of road landscape design variants and 3D (three dimensional) modelling in Sketchup and Lumion computer programs for a section of a road landscape of the major road A7 in Latvia.

Materials and Methods

Section of the major road A7 is chosen for a field study due to certain criteria. Latvian Tourism Development Guidelines 2014–2020 foresee the development of cross-border cooperation and include Latvia as a tourist destination in the market of the Baltic sea region countries (Latvijas tūrisma…, 2014). The road A7 is part of Pan – European Transport Network and transport corridor 1A. The entire route passes through cities such as Lübeck – Gdansk – Kaliningrad – Šiauliai – Jelgava – Riga – Valka/Valga – Tartu-Narva – St. Petersburg, which is an important tourism route connecting three Baltic States and other countries.

The pilot project is carried out in the territory, which represents one of the most characteristic types of landscape in Latvia – the agricultural landscape. The research took place from September, 2017 to February, 2018. In the future, it is planned to develop 3D models for two more territories in the forest landscape and mosaic landscape.

The chosen section covers 2 km². The length of a road section is 1 km. It is chosen due to the result of a model, which is a 3D animation representing real time movement along the road. With a driving speed of 90 km per hour it takes 40 seconds to look at the model. The road landscape corridor was considered

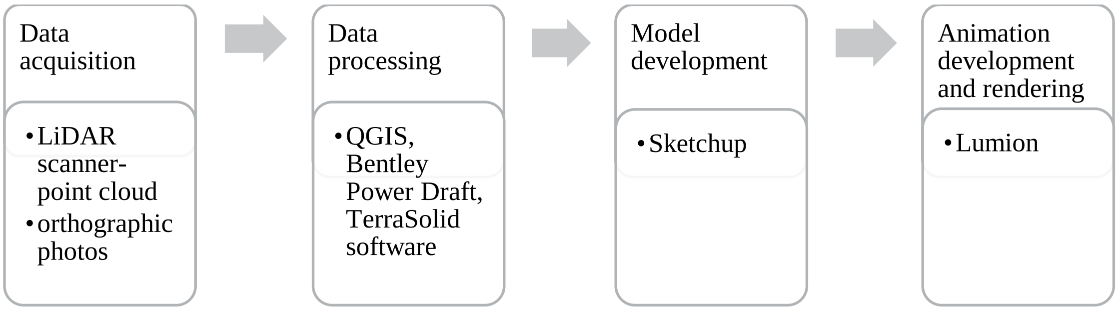

Figure 1. Workflow of the data acquisition and modelling process.

to be 1 km to each side from the central axes of the road according to the praxis of road planning (Slēde & Vikmanis 1980).

Laser scanning and photogrammetry were carried out on the road section of 2 km² to obtain topographic data and aero photographs for 3D modelling. Using GoPro camera, mounted on the car, videos for the road section in both directions were taken. Photographs of road side elements, e. g. a bus stop, were taken.

Workflow of the data acquisition and modelling process is presented in Figure 1. and is described more in the section 'Results and Discussion'.

Computer program SketchUp was used to develop 3D model for the territory. Details of road infrastructure, e.g. signs, road lines and precise places of trees and building were designed in Sketchup software. Lumion software was used to add trees and render the landscape.

Results and Discussion

Data acquisition

In order to develop a road landscape model, a topographic map was necessary. In our case the area is very large, and it would be time consuming and expensive to use common land surveying methods. Laser-based mobile mapping technologies (LiDAR) have become well – established surveying techniques for acquiring geospatial information, and transportation agencies around the world have considered LiDAR for road inventory (Guan *et al*., 2016). Point cloud from the LiDAR inventory can be utilised to perform road inventory mapping, including any road-scene structure, road pavement, traffic signalling devices, etc. (Williams *et al*., 2013; Landa & Prochazka, 2014). In this project, this system was used only to acquire topography data and geo-referenced aero photography. Using the LiDAR scanner Yellow Scan, surface terrain point cloud model with terrain networks of 50 m each, in scale 1:2000, and orthographic photos were acquired. The point cloud shows vegetation and other details, e.g. buildings. The YellowScan scanner was selected as it can go through vegetation, making it possible to produce a highly accurate digital surface model (DTM), as well as point density of 60 pts per 1m². The system allows to collect data (point cloud) very quickly and in good quality, and it can be processed with licensed computer programs. There is no need for a Civil Aviation Permit as the drones (unmanned aerial vehicles) fly 50 m above the ground.

It took three hours to perform object surveying. The flight heights were different, because the terrain was not at the same height everywhere – in the lowest place it was 30 m, but the highest – 70 m above the ground level. The flight speed was constant everywhere – 20 km h^{-1}, which allowed to achieve a good point intensity and make the exact surface model on average 70 points per square kilometre. The land owners were personally informed before the flight about the purpose of the surveying.

Data processing

The flight data were verified on-site using the QGIS and YellowScan plugin. The pilot then performed data alignment and transferred data to a geodesist who carried out data analysis and data processing using the Bentley Power Draft and TerraSolid software.

In some places, where the density of vegetation was 100%, the laser impulse did not pass through. There were few such sites and no defects in the overall model of the relief were detected.

Model development

Three landscape design versions based on the current topography, agricultural land use and road infrastructure were developed. These versions show the current situation and two different landscape development possibilities depending on intensity of the use, management, and application of road landscape design principles.

First version shows the current situation with agricultural landscape, some trees and shrubs in the ditches, current road infrastructure with information signs, a bus stop, electricity lines, households with the surrounding yards and trees.

The second version shows more open, well managed landscape with intensive agricultural use, wide and distant views. In order to acquire this, shrubs and small trees, which grow in ditches, are not included in the current model and one house close to the road, built in the Soviet time is not included in the model. Current road infrastructure with information signs, a bus stop, electricity lines, historical households with the surrounding yards and old trees are present in the model. There are minimal, regularly cut edges along the fields.

The third version differs with more tree groups in the model, placed according to road landscape design methods – wider edges along the fields.

Sketchup software was used for the road 3D modelling from a topographic map, which was imported as .dwg file. As the Sketchup software offers a limited number of tools for modelling, especially for road and terrain modelling there was a need to use several programme extensions. The road was modelled with Chris Fullmer Shape bender extension. The road model was created from the road profile line with this tool. For the terrain modelling a sandbox tool was used. It was followed by Curviloft and ThruPaint extensions for positioning and orientating the road texture. Large tree groups and buildings were marked in the topography from LiDAR data, some of separate

Source: by A. Mengots.

Figure 2. Sketchup model with the marked places for trees.

Source: by A. Mengots.

Figure 3. Model of the current situation rendered in Lumion.

standing trees were marked using the geo-referenced aero photo, which overlaid the topography in AutoCad.

As we developed three design versions, an aero photo was used to check the size of the trees and to decide about the design, which elements to keep and which to remove. Two dimensional linework tree CAD blocks, which were replaced by 3D tree placement mark components, can be seen in the imported topographic map, see Figure 2. This option allows to arrange tree marks instantly and precisely. The right height of the object placement on terrain was carried out with DropGC extension. For a more authentic look of the road, landscape houses, bus stops, road signs and electricity lines were added. They were designed in Sketchup using the photos of the elements and the video taken by GoPro camera.

Animation development and rendering

Sketchup model was imported into Lumion 8 to add trees and to render the landscape, see Fig.

3. Lumion 8 is a real-time game engine rendering software with LoD (level of detail) algorithm. This algorithm allows to model large areas covered by trees because it decreases the geometry of an object depending on virtual viewer's location. If the viewer is close to the object, it will be displayed in detail. If the viewer is far from the object, it will be displayed in a less detailed way. Cars and movement were added in Lumion as well. The latest Lumion improvements for the sky light feature and shadows allowed to blend all landscape elements more naturally and get the final rendered animation more immersive and realistic.

Animations and the current situation captured by GoPro camera will be demonstrated to the road users in the next step of the project and questionnaire about these developed variants will be prepared. It will give the possibility to analyse how road users understand the proposed changes, the pros and cons of such an approach and to what extent such type of animations is suitable for road landscape development evaluation and planning.

Conclusions

Data acquisition for topography by using LiDAR scanner is fast and efficient. It is the appropriate technology for large scale projects demanding precise topography.

The experience gained from the project shows that Sketchup software itself has a limited set of tools. However, the use of various available plugins increases the modelling capabilities.

Lumion is a powerful tool for upgrading CAD models and rendering. The real time navigation in virtual environment and its simple interface gives the possibility for an ordinary architect, landscape architect and planner to use it. But more realistic representation of vegetation should be worked on. Also, the library of vegetation models is quite limited.

The questionnaire of road users will show to what extent such animations are suitable for the evaluation and planning of road landscape development. There is a hope to get closer to the answer to the question – what 'good enough visualisation' for effective planning is.

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