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USE OF PHOTOGRAMMETRIC DATA WITH TOOLS FOR ADVANCED VISUALIZATION OF THE NOSTITZ GRANGE IN MŚCIWOJÓW

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Summary

The article describes the results of research into the possibility of the integration of spatial data available in the centers of geodetic and cartographic documentation for the modeling and visualization of rural areas, as well as the procedure to be followed from the analysis of spatial data available through their acquisition, verification and processing procedure for modeling and visualization. In article, the authors also describe issues of optimization data for all process.

Keywords

spatial data • 3D modeling • visualization • optimization

1. Introduction

The present research has been computed in the framework of the activities related to the pilot project funded by the University of Agriculture in Krakow within the project: "Valorisation and sustainable development of cultural landscapes using innovative participation and visualization techniques – VITAL LANDSCAPES", no. 2CE164P3.

Three-dimensional techniques have been present in the practice of architectural and urban design for over 20 years.

When creating design studies on rural areas, the use of such techniques have several advantages:

- simplifies decision-making when shaping the landscape due to the ease of evaluation of individual dominants, openings, etc.,
- facilitates the search for architectural forms for newly placed objects (in the process of creating a 3D model for the existing state it is natural to develop a feasibility study of the architectural form and specify the existing means of the architectural language, used materials, historical constructions etc.),
- three-dimensional visualizations is simplifying communication with the recipients of the project [Brożek et al. 2013] (The message of the design is clearly read

and easier to see or assimilate than conventional design documentation when final elaboration is presented in the form of visualization and 3D animation).

Complex three-dimensional visualization usually contains:

- terrain,
- vegetation (areas covered with a specific type of plants),
- layout of communication,
- layout of buildings in the form of,
- simplified geometry,
- geometry of the unique elements,
- small architecture elements (road signs, lamps, benches, etc.),
- elements of a style of art (cars, human characters, signage, etc.).

Three-dimensional visualization process steps are:

- concept design,
- elaboration of design documentation,
- development of digital model of the terrain,
- creating of 3D models of existing state,
- creating of 3D models for proposal,
- declaration of materials and textures,
- development of point of interest (cameras),
- development of lighting-rendering test-optimization-rendering finished.

The above points representing the process can be performed in alternating or in reverse order.

When an accurate 3D model of an existing state is build at the stage of conceptual design, the design planners can keep using all the spatial data, all the mutual relationships between volumes and thus verify the accepted concepts of the design. A three-dimensional model can be an invaluable aid when working of the project.

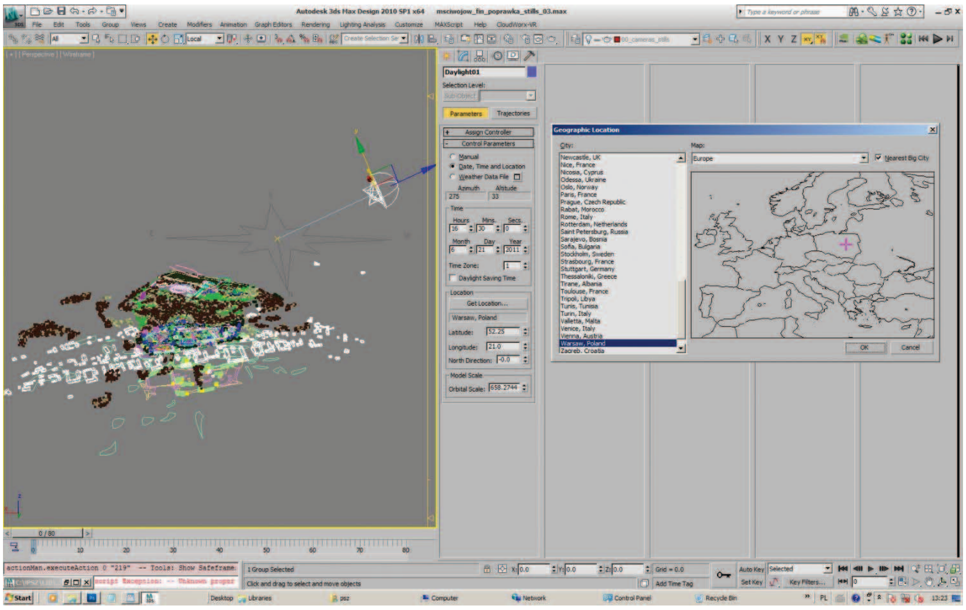
Contemporary technology allows for the creation of 3D visualization in two general ways:

- Real-time rendering, based on modern GPU hardware. First developed for the video game industry but now widely used in industrial and military simulations and introduced into spatial data visualization. The result of visualization is an interactive 3D model. The main advantage of this approach is that it allows many changes to be done in "real-time". A good example for this is "Placeways CommunityViz Scenario 360" [http://placeways.com/communityviz/productinfo/scenario360/index.php]. This is GIS-based decision support software for regional and local planners. Scenario 360 is an interactive analysis tools and a decision-making framework to the ArcGIS platform. Scenario 360 helps planners view, analyze and understand land-use alternatives and impacts. The drawbacks are poor quality of the generated visuals because of the three-dimensional model complexity limitations when compared to offline renderings, requirement of expensive graphics cards and the professional skills for creating procedural content (real-time solutions are beyond this elaboration).

- Offline rendering, the classical approach where final visualization results are still images or animations generated out of a developed 3D model. The elaborations with offline rendering requires three-dimensional graphics editing software with rendering engine for image generations.

There are many professional tools for creating advanced three-dimensional visualizations in a offline rendering manner in today's market such as Maxon Cinema 4D, Luxology Modo or open-source Blender to name a few. However, Autodesk 3dsmax is one of the most universal application for creating and editing 3D graphics and it can create a full spectrum of work.

Developed since 1990 (first versions for MS-DOS), it is commonly chosen as a tool to create architectural and product visualization, and also to create modern video games and special effects in the movie industry. Due to the open structure and the versatility of maxscript (internal language of 3dsmax), thousands of users and independent developers are able to adjust the software to their needs. The built-in rendering engine – mental ray – enables you to perform precise visualization, using the energy balance of lighting in a 3D scene, while maintaining the physical properties (energy conserving) of the materials used. The entire process is perform in the linear (32 bit) light model.



Source: authors' study

Fig. 1. Daylight System

Due to the physical correctness and the combination of these techniques and simulation of daily lighting (Daylight System, Figure 1), it is also possible to carry out the simulation of transition of sunlight from sunrise to sunset for a specified geographic location and season of the year. Many modern rendering technologies allow for the simulation of atmospherics effects like rain, snow and cloud status. All this technology results in the high photo-real effect of the generated images, especially when combine with real world spatial data.

2. Creating a model

The use of DTM (Digital Terrain Model), aerial photographs in conjunction with the obtained data from CODKiG aerial triangulation, led to the development with digital photogrammetric station:

- DTM in the form of a triangle mesh TIN optimized for modeling and visualization,
- 3D model of the existing buildings,
- orthophotomaps of selected area which then served as the foundation for the design and the texture of DTM in the process of visualization.

The study was performed on a digital photogrammetric station, DEPHOS in the coordinate system 2000, a topologically correct DTM together with the 3D model of buildings was exported into DGN. In this case, of particular importance was the impact of correct model topology of intersections and links objects in the Z axis (extensions, roofs, buildings with an area of intersection).

The main problem, which appeared as a result of such a defined modeling process and visualization, is the variety of software used at every stage and thus a variety of formats in the resulting data. It enforces the redefinition of data exchange formats between successive stages of development, on the assumption that the operations of import / export data do not cause data loss or deterioration. To enable the integration of 2D and 3D data from a variety of environments, it is necessary to give everyone a georeferencing and maintain it for transferring data between successive stages of development. In the case of a project for Mściwojów, the use of photogrammetric data (DTM, aerial photos, aerial triangulation) drove the adoption of the coordinate system 2000 as a whole development.

Photogrammetric inventory of the existing state allows for three-dimensional reconstruction of buildings (Figure 2) and spatial development for a given area. It allows for accurate modeling and visualization. Photogrammetric inventory of objects is performed by means of digital photogrammetric stations and gives as result the vector model in the local coordinate system of an object or defined by reference to the geodetic coordinate system. The data interchange format for digital photogrammetric station is dxf format.

Digital Terrain Model introduces a third dimension into the design. For areas with complex terrain it is a big aid in making any decision related to project volumes and the amount of newly designed buildings and evaluation of the impact of this

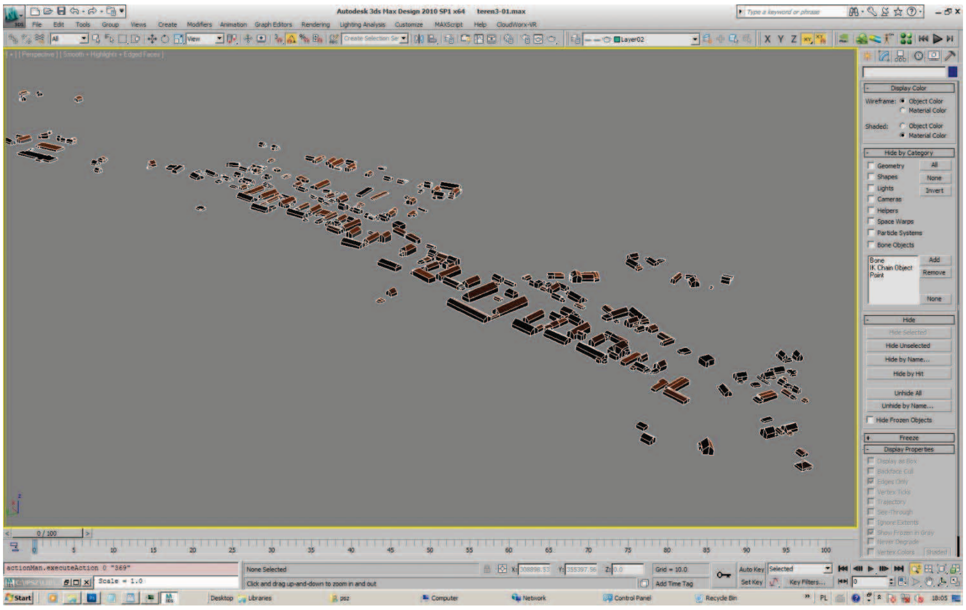


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Fig. 2. Existing buildings model

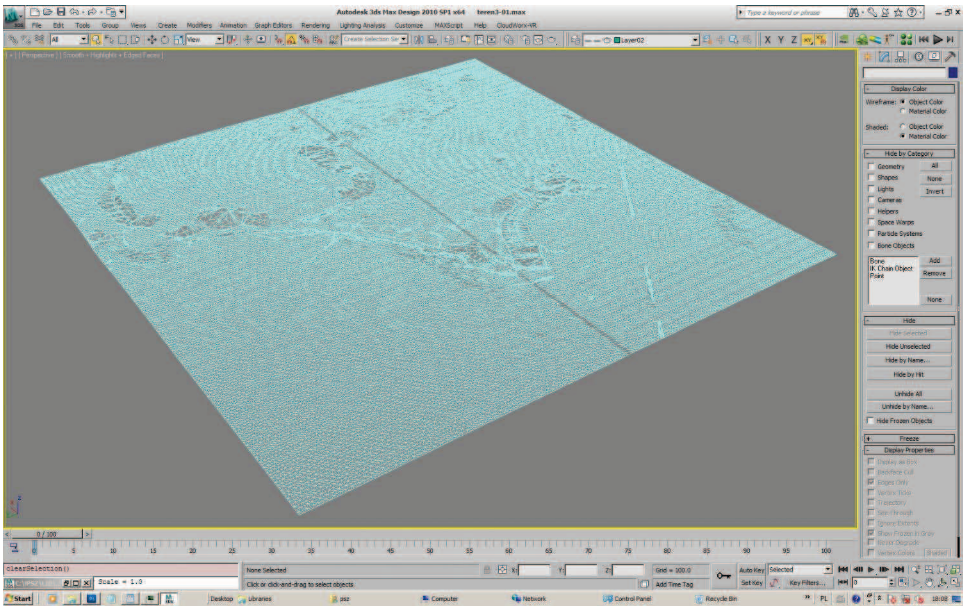

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Fig. 3. Digital Terrain Model

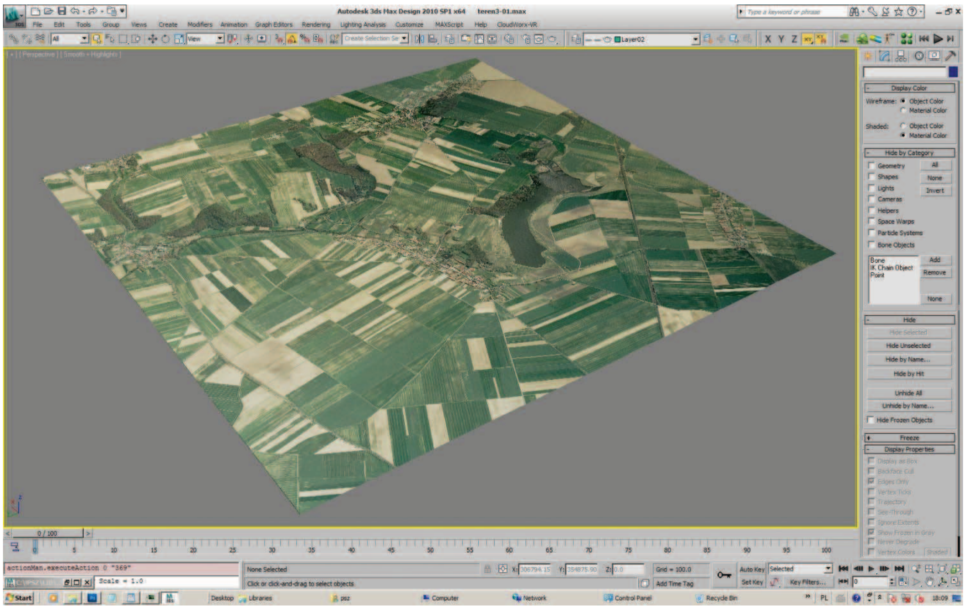

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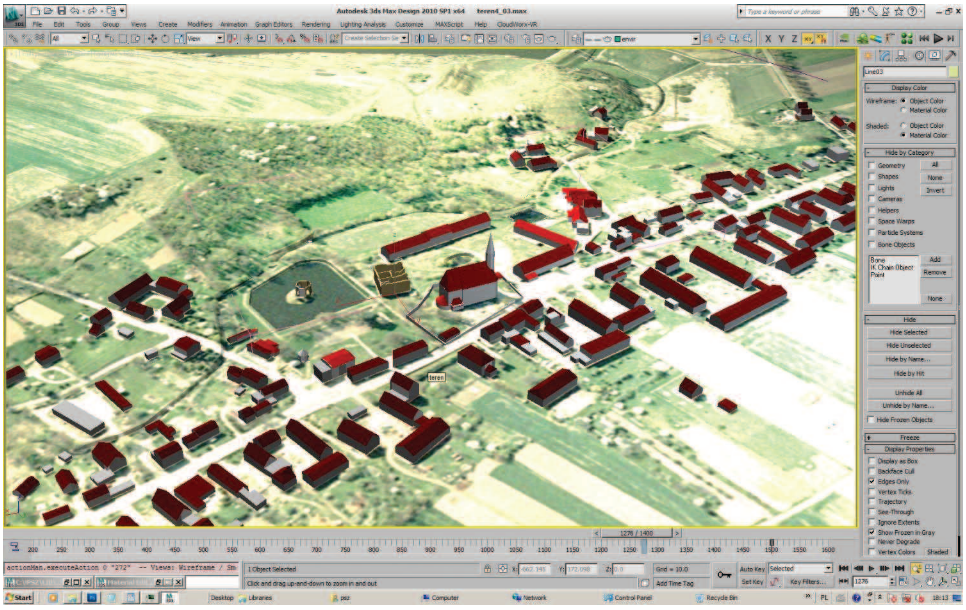
Fig. 4. Orthophotomap



Source: authors' study

Fig. 5. Existing state of village

decisions on the existing buildings. In the case of the present project, DTM was obtained in ASCII format in the coordinate system in 2000 at about a 10 m grid mesh made from analog photos of scale 1 : 26 000. On the basis of these data TIN model was generated (Figure 3).

Orthophotomap was made from prepared Digital Terrain Model and aerial photographs. It enables photo-realistic representation of land use and it can be used as texture in the process of visualization (Figure 4).

As a result of combining a DTM and 3D model of buildings and orthophotomap, the existing state of an area of interest was achieved (Figure 5). This is the starting material for further work on the visualization of development of spatial projects.

3. Import from CAD software

The simplest and most obvious way to create 3D visualization is to import geometry data from CAD application that manages the development of design.

Depending on the format through which you can perform the import geometry (the most important is FBX, STL, IGES, OBJ, DWG, DXF), you can transfer between applications additional information (definition of materials, lights, cameras, layers, blocks, etc.).

Within the types of EditablePoly and EditableMesh for 3D objects, you can perform all the work related to the import of 3D models created in external applications (CAD) and the preparation of such a geometry to the final visualization (i.e. a declaration of materials for each surface and setting the lights and cameras).

But creating a visualization on the basis of direct data exported from CAD is not the most effective solution. The main disadvantages of this approach are:

- errors in the process of translation between different applications (such as double faces),
- frequently non editable (closed) resolution of 3D model, defined during export of CAD, or import into 3dsmax,
- 3D model derived from external sources (a layout of vertices or "the wall"/"3dface"), is considerably difficult or even impossible to easily adapt to distance from the camera and rebuilding of the model is needed when presenting fine detail,
- necessity of rebuilding the model caused by further editing needs (preparation of materials mapping, texturing or advanced lighting in 3dsmax).

4. Creating visualization in 3D graphics editing software environment

The most effective way of creating 3D visualization in a larger design team is the usage of 3D graphics editing software. It gives much better visual effects to create a visualization for a 3D scenes, built from scratch in 3dsmax (or other similar 3D software of choice) because of appropriately filtered information from the source application, in parallel to the development in CAD programs. This approach allows the most efficient use of all the tools, techniques and ways to edit 3D models. The most important are those that make it possible to create 3D models and then modify them at a higher level than 3D faces base mesh. One can introduce into workflow many advanced techniques like parametric modeling:

- basic parametric objects (primitives) – easy to change dimensions, adapting to the needs of geometry resolution, automatic generation of mapping coordinates for textures,
- complex parametric objects and generated procedural objects,
- modeling using spline curves (adjustment up to the needs of geometry, including segmentation of arcs, automatic generation of texture mapping coordinates along the curve).

Another valuable feature is the history of modeling decisions like Modifier Stack.

5. Concept of the Modifier Stack and the philosophy of non-destructive workflow

As a result of combining a DTM and 3D model of buildings and orthophotomap the existing state of an area of interest was achieved. This is the starting material for further work on the visualization of development spatial projects.

The term "non-destructive workflow" means "to work with no loss of information", on the basis of which the 3D model was created. During all the process, the history of performed changes are stored and one has the chance to move back at any stage of the process. Advanced 3D graphics editing software, like 3dsmax, allows work in such a manner, in many aspects of the operation. The core to this approach is Modifier Stack in which various modifications of the 3D object are placed entirely or with selected parts. It is enough to create a "recipe" for an object to describe its parameters, build it with a set of relevant modifiers and any changes. The need to comply with variants of the object are very easy.

6. Instances and references: optimization of resources

The requirement for RAM is exponentially growing due to complex visualization operations and calculations related to the process of rendering. In relation to the demand, when rendering it is needed approx. 4 to 6 times (4 GB becomes 16 GB) more of RAM memory then editing the geometry. It is a given fact that is necessary to load into memory all the textures and generate the final resolution of the geometry at one time. Usually, the best way to deal with this problem of textures is to generate special counterparts called proxy.

Creating visualization often requires the introduction of multiple copies of the same object. In order not to increase the demand for resources for repeated copies of an object, 3dsmax can perform copying in the form of instances or references. This works like the blocks system in CAD programs.

Instances: all properties of objects are interconnected and changing any parameter for any instanced object, changes the parameter within all instances.

References: the object from which you started copying becomes the source for changes to the parameters for the others.

Instances and references may be treated with translations independently. In particular, the possibility of an independent non-uniform scaling of instances becomes crucial for generating complex vegetation cover. Instances and references system also works for all of the modifiers in the Modifier Stack (multiple objects can share the same modifier).

For optimizing geometry, 3dsmax offers mentalray Proxy or VRay Proxy systems. Special objects are generated and loaded into RAM, exactly on demand when the graphics rendering engine is generating the image fragment, in which this object exists.

The most effective external procedure for this is ForestPackPro. It covers the virtual terrain with millions of plants, as well as the management of this area. Plug-ins much better solves resource management (RAM) in an average workstation than the standard 3dsmax tools. In conjunction with the Proxy rendering engines; mentalray or VRay allows effective and rapid visualization of huge areas using models with unlimited number of faces (3D scene may contain billions of polygons (Figure 6).

Source: authors' study

Fig. 6. Vast three-dimensional environment visualization

7. Results

It should be noted that at present there is no software package to carry out the entire process comprehensively and efficiently from start to finish. This is due to the multiplicity of sources from which various data are derived and are necessary to develop a comprehensive project proposal, publications and presentations to all stakeholders. Often expectations and the needs of the various participants in the design process are divergent. In turn, this forces the use of multiple tools: CAD programs used by designers and dedicated graphics editing programs to generate final three-dimensional images and animation. Because of the different formats and different definitions of various vendors the process itself does not run seamlessly. At the same time, there is a perceptible difference between CAD software and programs for editing three-dimensional graphics.

The main advantages and disadvantages from the point of view of the design process associated with the limitations of existing solutions are as follow:

- CAD software advantages:
  - engineering degree of accuracy,
  - simultaneous generation of technical documentation,
- CAD software disadvantages:
  - inability to manage complex three-dimensional models, especially complex models of plants (CAD software is very insufficient to simulate a real land cover and the result of this is poor quality of the generated three-dimensional visualization),
  - poor tools related to animation,
- programs for 3D graphics editing advantages:
  - easy to create animations,
  - photorealism in created visualizations,
  - effective techniques for managing complex three-dimensional models,
- programs for 3D graphics editing disadvantages:
  - decreasing the accuracy of the transformation associated with the distance from the origin (3dsmax does not have a georeferensing tools).

In the practice, much of the work performed by the CAD team and a team dedicated to visualization of 3D scenes overlaps the same work has to be done by different staff, at different stages of the process. This problems can only be addressed with the deep knowledge of scripting languages for every software used.

8. Recapitulation

Creating a three-dimensional model based on actual data facilitates communication between all parties involved in the process. A precise three-dimensional model, created with no loss of data and attributes for subsequent transformations, should be the most important tool at all stages of the process.

The decision arrived at after a Summary of the work results, on the visualization of Nostitz grange, is that it is much better to directly use polylines from CAD software, to develop a design. The lines constituting the drawings of each object (terrain, roads, buildings) can be moved into 3dsmax (or any other 3D editing software) in a much more effective way than with the 3D mesh model (DXF/DWG). At the time of export, it is enough to separate them according to what they show and then save the coordinates of these splines into text files with the appropriate attributes (height of buildings for strokes depicting buildings, the width of the carriageway for the road axis, name of objects or areas etc.). Then with all this information, describing the various types of objects, you can play in 3dsmax using the procedural, non destructive approach.

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