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DATA PREPARATION FOR THE PURPOSES OF 3D VISUALIZATION

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Summary

The article presents a method of preparing input data for 3D visualizations. The authors implemented the proposed procedure when they were working on a visualization, with use of Autodesk 3ds Max software.
The test object were the ruins of a historic grange that belonged to the Nostitz family in Mściwojów (Mściwojów commune, Jaworski district, Lower-Silesia Voivodeship). After surveying the area and analyzing the data, using MicroStation with a geodetic application MK (Mapa Kontekstowa – context map), a Digital Terrain Model (DTM) was created along with contour lines, with use of Data Acquisition (a tool in some programs of Bentley). Next, the models of spatial objects were created using the authors' software VITAL LANDSCAPES Tools, developed during the EU CENTRAL EUROPE program. It was the basis for development of a visualization of current land management, using the software Autodesk 3ds Max. This allowed the design of the future land management of the historic grange so that the landscape balance is maintained.
The data processed in this manner can be used for photorealistic visualizations in Autodesk 3ds Max or other graphical software.

Keywords

Digital Terrain Model • cultural landscape • 3D visualization • photorealistic visualization • data conversion

1. Introduction

One of the ways of protecting cultural legacy is proper management of space [Gołuch 2003]. It is getting simpler to protect and manage space, thanks to modern tools such as platforms for modeling and digital visualizations (e.g. Autodesk 3ds Max). They provide the opportunity to develop complex projects related to various areas, for example to model and visualize in photerealistic way the land management [Batty et al. 2000, Drettakis et al. 2006, Pawlak-Jakubowska 2012].

As a part of VITAL LANDSCAPES project, the test object of the ruins of the historic grange of the Nostitz family in Mściwojów, a visualization was made with use of Autodesk 3ds Max software. Spatial (geodetic) data from the measured object and photographic documentation were essential for this purpose [Pundt 2000]. Visualization of the present state allowed to incorporate new infrastructure and to evaluate if, it fits the landscape.

The data from field measurements was processed using MicroStation software (a Bentley product), with a dedicated geodetic tool MK – Mapa Kontekstowa (a product of GeoDeZy company). This set (MicroStation software with MK tool) comprises the basic tool of geodesists, to modify spatial data. Basing on thid tools, a Digital Terrain Model was created along with models of buildings in the Data Acquisition application. This was also working in MicroStation environment.

The attempt to export a 3D model from MicroStation to Autodesk 3ds Max confirmed that the input data prepared in a different environment can be inconsistent. This is due to the fact that it contains different kinds of spatial information [Hejmanowska et al. 2008].

Analyzing the inconsistencies that occurred, allowed the development of a procedure for organizing the input data during the process of creating a visualization [Belcher 2006, Bojarkowski and Gościewski 2008, Gläβer et al. 2010]. Also, special software was developed, which assisted with closing the polygons made up of single elements (segments, arcs) and rises the elements to the terrain surface. These are determined by the grid of triangles of the Digital Terrain Model.

2. Research description

The data necessary to make a DTM can be prepared using different measuring methods. This creates therefore different errors. In the studied object of the ruins of the historic grange, the analyzed data was gathered through tachymetric measurements and GNSS (Global Navigation Satellite System). The materials needed to be organized by recognizing the contents of particular layers. This allows for the easy selection of layers, where the objects were contained using these automatic tools. The standard process's to filter the data from different measurement methods by their usefulness.

2.1. *Data Acquisition* tool [Kaletowska 2012]

The next stages of work required a tool to construct a Digital Terrain Model (DTM) for Data Acquisition. This is available as software offered by Bentley (PowerSurvey, PowerCivil for Poland, InRoads, GEOPAK, MX). It allows for the import of data originating from various software:

- measured data,
- raster models of spatial data and,
- Digital Terrain Model formats.

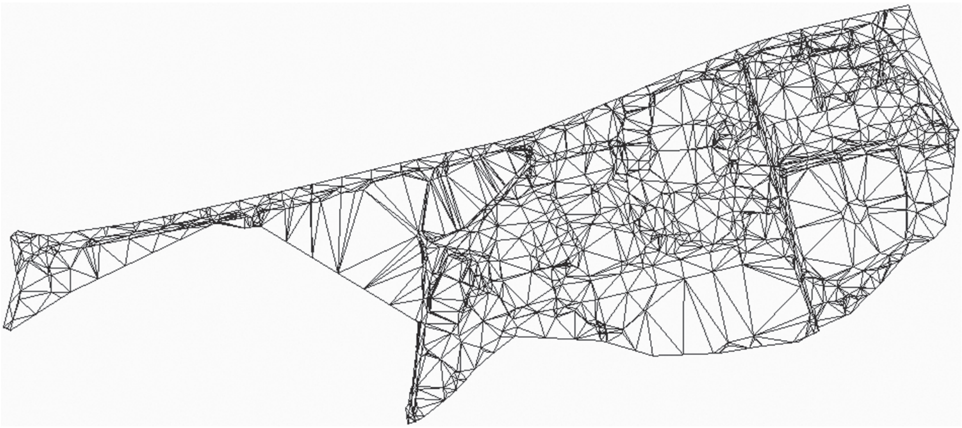
Due to this process, all the data is connected and saved in one "*.dgn" file and then can be exported to different file formats.

Preparation of input data, that contain large quantities of elements require carefully distinguishable graphical objects, such as:

- scattered height points,
- discontinuity lines or
- boundaries of the map

are required to be placed on different layers. These layers names would suggest their contents. The layers will serve as a base for a Digital Terrain Model (DTM) that consists of triangles network (TIN – Triangulated Irregular Network) and isolines for the analyzed area. These will be generated automatically using the Data Acquisition tool. The triangles network and isolines are stored on users surface (Surface) in features (Features) of triangles network (Triangles) and isolines (Major and Minor Contours).

Generating a Digital Terrain Model (DTM) in the form of TIN (Triangulated Irregular Network) is an automated process based on the imported data. Input of new elements results in an automatic modification of Triangles and Major and Minor contours.



Source: Gryboś 2012

Fig. 1. Triangles Network generated by *Data Acquisition* tool

The generated TIN form is required to be verified by the user, if the triangles form created by the program is correct. At this point, it is possible to modify the selection of points and lines that the TIN and the contours are based upon. Tools for creating a Digital Terrain Model (DTM) also offer additional options, such as defining the maximum length of the TIN. This can eliminate the unreliable propositions of the network, at the stage of creating the model [Majde 2011].

A ready surface in the form of Triangulated Irregular Network (TIN) can be exported to "*.dtm", a universal format for storing Digital Terrain Model. This also allows for a possibility to save and store the model in a "*.dgn" file.

Using the Data Acquisition tool, the last stage of the procedure is creating the isolines, and then adding the contour lines with a specified interval into the "*.dgn" file. The contour lines are divided into primary and secondary lines. Placing them on different layers, depending on the interval set by the user, allows the user to adjust the clarity of the image. All contour lines below the zero level and their descriptions lay on separate layers.

Source: Gryboś 2012

Fig. 2. Output data: network triangles supplemented with contour lines

2.2. VITAL LANDSCAPES Tools Application [Gryboś 2012]

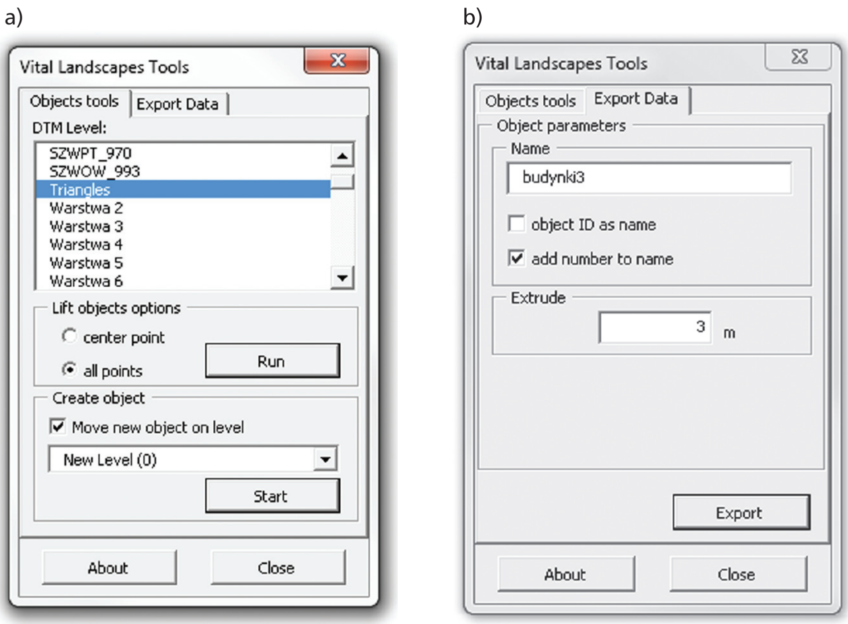
In the next stage, with the use of VITAL LANDSCAPES Tools application, the triangles of the network are used to project objects of the map onto the terrain. Meanwhile the contour lines will be the basis for developing a visualization in Autodesk 3ds Max.

VITAL LANDSCAPES Tools, on Bentley's CAD software was designed and developed as a part of the VITAL LANDSCAPES project, which is a part of CENTRAL EUROPE program. It assists in creating objects by closing the polygons made of single linear elements (segments, arcs) and raising the elements to the level defined by the TIN, of the Digital Terrain Model.

The functions of the VITAL LANDSCAPES application are contained in two windows. The first part of the window is named Object tools (Figure 3a). With its use, one can place selected geometrical forms of an object on a given surface of a Digital Terrain Model. This function requires a previously prepared surface, such as a Triangulated Irregular Network. Due to the function *Lift object options*, the objects drawn on different heights in project space of the file can be adjusted to any planned surface. This means, that they can be placed to a new height without copying them.

Objects can be moved in two modes:

- *center point* – when lifting the object, only the height of the centroid is taken into account,
- *all points* – each point of a geometrical object is independently lifted to a 3D model.



Source: Gryboś 2012

Fig. 3. *Vital Landscapes Tools* application: a – *Objects tools* window, b – *Export data* window

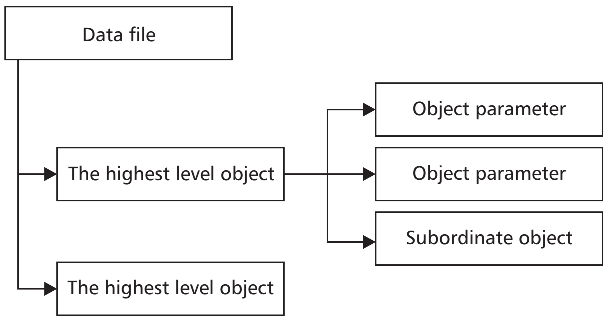
The second part of *Object tools* window – *Create objects* is used to perform the so-called objecting. Objecting is a process by which the user creates one consistent polygon out of many linear elements (segments, arcs). This is accomplished by closing the shortcomings and intersections with a preset tolerance. Dynamic creation of polygons by pointing to linear elements of an area or a shape which will replace the partial elements. This function allows the possibility to model regular objects, such as buildings.

The option *Move new object on level* is used to control the placement of new objects. Depending on the selection in this window, a new element will be placed on a layer, on which the connected linear elements are located or on a dedicated layer, for storing newly created objects. Their location in space is dependent on the settings of active height in the drawing.

At this stage the objects connected by the function *Create objects* and objects created without using this function are flat. In the second window of the application, called *Export data* (Figure 3b), the *Extrude* function allows the creation of solids out of these elements. This means that selected closed elements will be expanded to the 3rd dimension and will have the height determined by the user.

When it comes to exporting different types of objects, it is best to do it by incremental steps. This allows for the proper assignment of height to buildings, depending on their type. Additionally, approximate heights of forests are modeled.

Objects created in such a manner, will be stored in a special text file with "*.dat" extension. As the format developed by participants of the project, shown below. The scheme of objects in a file is shown on Figure 4.



Source: Szelest 2012

Fig. 4. Scheme of objects in file

Special characters used in this format are described in Table 1.

Table 1. Special characters [Szelest 2012]

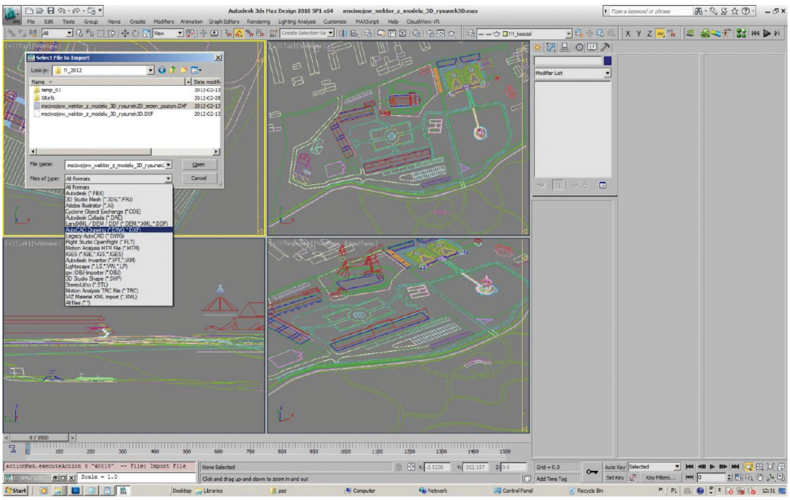
Special character table	
ENTER	The end of data processing with the end of line in text file (the end of lexical atom)
SPACE	Character omitted in processing
;	Separates the data in one line
--	Comment
#	Mark of the beginning of the highest level object
!#	Mark of the end of the highest level object
@	Parameter mark (simple variable)
:	Parameter value mark
[x,x,x,...]	Complex variable mark – table(for example 3 coordinates of a point in 3-D)

The formats used to exchange data between Bentley applications and *Autodesk 3ds Max* are listed below:

- The highest level objects:
  #SCENE – scene type object,
  #SPLINE – spline type object,
  #MESH – mesh type object,
  #CELL – point object (cell),
  #EOF – end of file.
- Parameters:
  @NAME – name of an object,
  @KNOT – knot,
- Type {korner, bezier},
- Points [x,y,z],
- Access path to the object:
  @TopVector [x, y, z] – zenith vector of an object ascribed to the knot,
  @MeshType – net side type (3 triangle, 4 quadrangle),
  @SplineClosed (true/false) – automatic closing of a spline,
  @Color [r, g, b] – object color,
  @Extrude [h] – height of closed objects (buildings, forests).

2.3. *Autodesk 3ds Max* application

Thanks to the application and use of the procedure the objects of the model were successfully imported into Autodesk 3ds Max (Figure 5). This was the goal of the procedure.



Source: Inspired by U. Litwin, developed in 3ds Max by P. Szelest

Fig. 5. Initially processed data in Autodesk 3ds Max views

Source: Inspired by U. Litwin, developed in 3ds Max by P. Szelest

Fig. 6. Photorealistic visualization of the test object made in Autodesk 3ds Max

The model was expanded during the processing (with use of Surfer software) to the neighboring areas which provides the illusion of a remote horizon [Zygmunt 2012]. Creating a model in a presented way does not require additional data, however, shows the outside of the area in a simplified manner.

Terrain model preparation was the basis for the photo – realistic visualization, but it is needed for landscape to show the designed object in its real environment. (e.g. to compose new infrastructure elements based on old ones and terrain). That's why photogrammetric method was used to get the DTM (Digital Terrain Model).

After creating DTM, the model was textured. The buildings were textured with ground-based photographs and the terrain was textured with aerial photographs, including area outside of the test object. Next, a model of firmament was added and energy balance was directed. This gives the shading effect.

The picture above (Fig. 6) shows a photo-realistic visualization made using photogrammetric tools [Mitka, Szelest 2012]. The same effect can be achieved as a result of the suggested by authors procedure.

At the stage of designing new infrastructure, a photorealistic visualization allows the possible addition of modern buildings such as an observation tower or sport objects, without destroying the harmony of the landscape (Figure 6).

3. Conclusions

Preparing the data for the purpose of 3D visualization is a very complex procedure. The authors suggest the following sequence of actions to make it simpler:

- Prepare the input data and arrange the "*.dgn" file containing spatial information about the analyzed area in Bentley software.
- Create a Digital Terrain Model (DTM) with use of the *Data Acquisition* tool.
- Place the objects on the terrain model with the use of the *Vital Landscapes Tools for MicroStation* application.
- Close the polygons and the spatial modelling of them with the use of the *Vital Landscapes Tools for MicroStation* application.

Data prepared in this manner can be used for making a 3D visualization in software dedicated for such purposes. For the purpose of VITAL LANDSCAPES, a photorealistic visualization was made in Autodesk 3ds Max. Any of all these tools can be used in the process of creating more complex visualizations.

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