A PROCESS OF GENERATING CITY MODELS BY MEANS OF DIGITAL PHOTOGRAMMETRY

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Summary

The paper gives an overview of procedures used to generate city models on the basis of photogrammtric techniques. The Phaust software system, developed by the laboratory of photogrammetry of University of Essen, together with a software company situated in Essen, is presented. Some actual examples, including video and internet presentation on the basis of virtual reality modelling language (VRML), are shown.

Introduction

The graphic representation of the physical features of a part or the whole of our Earth's surface, by means of signs and symbols, at an established scale and on a specified projection is generally done in a 2-dimensional way, using maps. The maps are stored in an analog or meanwhile in a digital way. Geographic information systems are used to combine geometric informations and versatile object data.
Maps are used for innumerable applications, for example administration, navigation, planning etc., but very often there is a special problem: the cartographic products normally can be used and understood only by specialists, but not by common people or decision makers and politicians. Living in an age of growing global information systems, this is a non-acceptable status. So, why not presenting information in a 3-dimensional way, like we can find them in reality?

Having the focus on a theme like town planning the process of planning is normally visualised by wooden models. Existing infrastructure and new plannings are combined, but often with a very generalised shape. The models are static, uncoloured (white or grey) and almost no informations about materials are available. Every change in the planning process requires a time consuming update of the model. In this case the use of digital visualisation techniques opens new prospects, supposing necessary digital data are available. Over years surveyors have developed various methods for data acquisition like topographic measurements, photogrammetry, laserscanning or versatile detectors integrated in satellites. Putting the focus on photogrammetric techniques it is obvious that data acquisition is done in a 3-dimensional way, a good precondition for every kind of 3-dimensional modelling and visualisation.

A typical application in this context is the building and presentation of city-models. Actual photogrammetric software developments are engaged in this theme. Using digital arial photographs in combination with digital ground cadastral maps, containing 2-dimensional informations of different objects, buildings and streets, an economic way of generating 3D city-models is available. The acquired data is equiped with very high geometric quality and can be used as basic information for future 3D geographic information systems.

Concerning visualisation this data is also usable for generating detailed digital city models. To improve the quality and identity of the models addi-tional terrestrial images are used for texturing the objects.

Data acquisition using a digital photogrammetric workstation
The development of digital photogrammetric workstations, particularly used in arial photogrammetry, is taking place for nearly a whole decade. With the availability of powerful personal computers, controlled by a Windows NT operating system, the investments which had to be done have been reduced rapidly. A lot of software products had to be adapted in this context; newly one's got on the market.

At the end of the year 1999 the laboratory of photogrammetry of Essen University, together with a software company situated in Essen, started developing a new digital photogrammetric workstation. It is called Phaust StereoModeler and its main purpose is the building of 3-dimensional city-models.

Fig 1: Phaust StereoModeler user interface

Fig 2 (next page): Data fusion, combining information of cadastral and aerial image data

Phaust StereoModeler
Stereoscopic measurement systems dominate the photogrammetric evaluation process for a long time. There are several requirements a modern system should fit:

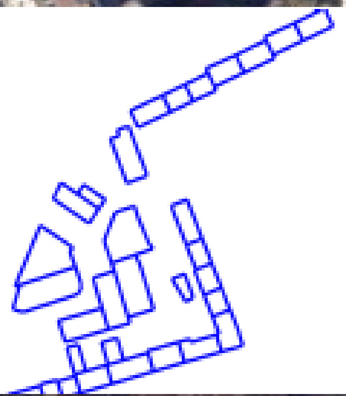
- Measurement and reconstruction of arbitrary object structures (points, lines, polygon, polyhedron),
- Texturing of object geometries in several levels of detail in case of visualisation of 3-dimensional object in a photorealistic way
- Unrestricted use of aerial and terrestrial images
- Availibility of automatic and semi-automatic functions during the evaluation process
- Flexibility in using in- and export data formats
- User-friendly operator interface and handling

The Phaust StereoModeler software package, built in an object orientated programming language (C++) guarantees modularity and flexibility. As a result extended features can be integrated in an easy way.

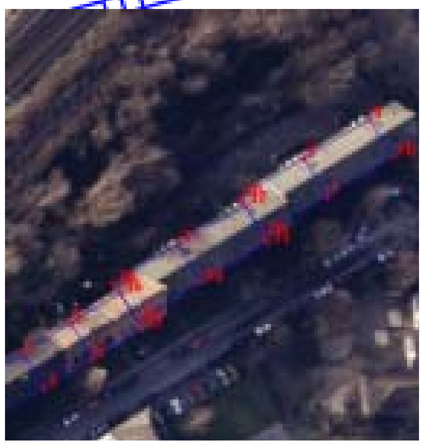
Figure 1 shows the application interface which is dominated by the left sided stereoscopic window. A small window on the right hand side is used to show the whole model in an overview, superimposed by measured elements. This view is a scaleable one and can be used to choose the parts of the images to be shown in the stereoscopic window. Some additional toolboxes complete the user interface. The whole process is controlled by a 3-button scroll mouse. As a further hardware requirement a stereo graphic card has to be available together with polarized eyeglasses.

Acquisition of geometric data

Using Phaust StereoModeler in building 3-dimensional city-models several strategies in acquiring data are available. In this context the digital ground cadastral map, containing 2-dimensional informations of different objects, buildings and streets, plays an important role. The evaluation process is starting in measuring a regular grid in the area of interest. By means of height interpolation a digital surface model is calculated. The 2-dimensional polygons of the digital ground cadastral map are then imported via a DXF-import into the Phaust StereoModeler. During this process an interpolated height is assigned to every imported point of the polygons. From now on the imported objects are equipped with 3-dimensional coordinates (figure 2).



The next step is characterized in measuring object heights, especially the one's from the buildings. Picking a suitable building's polygon in the over-view and measuring the correspondable height by stereoscopic means leads to an extruded building, which at last is divided in it's different planes (figure 3).



Various standard geometries, so called constructed solid geometries (CSG), may be recorded in this way, like

- Boxes (flat roofs)
- Gabled roofs
- Hipped roofs
- Half hipped roofs.

Several other CSG's are under construction.
If there is no ground data available the construction of a building may be started by measuring a spatial polygon at the top. Recording the height of a point at the bottom of the building or in the nearest neighbourhood enables the definition of the building's planes, which then are fitted to the ground surface.

The whole geometries may be exported to a CAD-program via a DXF-export, for example to Bentley's MicroStation. The data is structured in the same way as it is done in MicroStation (Figure 4).

Texture mapping
An other process which may be combined with the geometric data acquisition is the acquiring of textures from the arial photograph. This plays an important role in context with object visualisation, especially concerning roofs and ground surface. In case of a roof a spatial polygon has to be choosen in the overview window of the

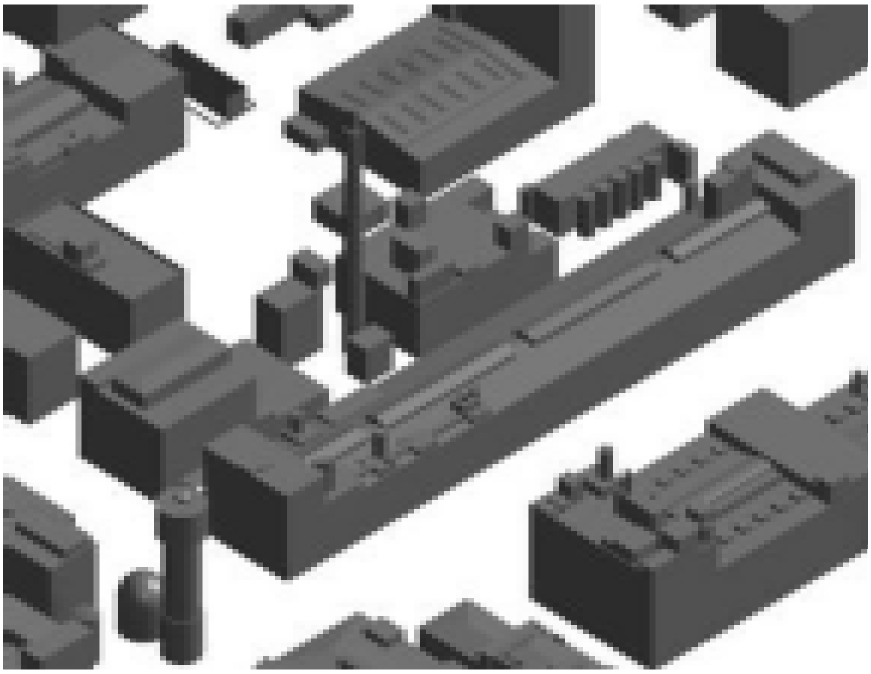


Fig 4: Rendered object scene onstructed with Phaust tereoModeler after export to MicroStation

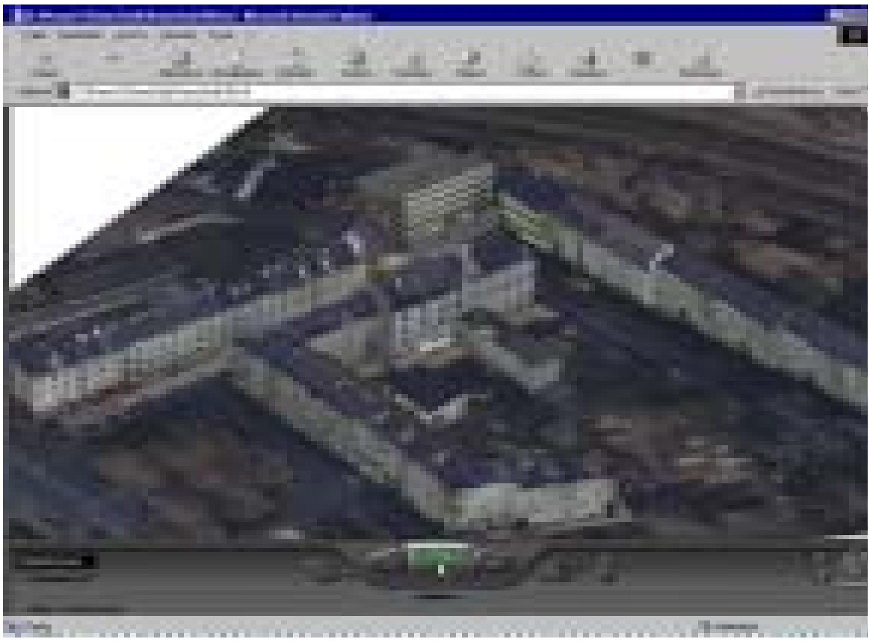


Fig 5: Part of a textured city model presented in a VRML

digital photogrammetric workstation and the suitable patch of the aerial photograph will be assigned to the polygon. In connection to the ground surface this process works totally automatic. The whole textures are stored in a JPG-format with choosable degree of compression.

The 3-dimensional object geometries together with their textures can be stored in a virtual reality modelling language (VRML) file format. This VRML-coded data allows an interactive, photorealistic representation of the object scene, especially in combination with the use in the world wide web. Figure 5 shows an example, presenting a part of a scene from Essen city.

Generally it isn't possible to assign textures to vertical planes from the aerial photo. To get these informations additional terrestrial photos have to be taken, preferably by the use of small digital consumer cameras (Figure 6).

Fig 6: Digital consumer camera:
Olympus Camedia E10

An image resolution of 1280*1024 pixel normally is enough for a good object presentation. Ordinary some problems arise when taking the digital photos, concerning geometry (perspective distortion) but also radiometric distortions. These image deformations have to be corrected by suitable programs like Phaust TextureModeler (Figures 7 and 8 give on overview of some typical effects).

As a final result modelled objects get a photorealistic appearance with a high degree of identification (Figure 9).

Features and possibilities of virtual reality modelling language
To present city models one can choose a lot of possibilities to do so. One of the most interesting is the virtual reality modelling language, so-called VRML. It is an international standard to describe interactive 3D-graphics in the internet. The language was defined in 1995. The actual version is the so called VRML97, sometimes also called VRML2.

Fig 7a: Original perspective image
Fig 7b: Prepared texture after image processing

VRML is a platform independent language; the scripts are stored in an ASCII-code. The simplest way to generate this code is to use an ASCII editor, the most easiest way is to use an authoring tool or the integrated interfaces of high sophisticated CAD-programs. One of the best tools in this context is a product of the Autodesk line called 3D Studio Max (figure 10). It is a typical tool for the trickfilm industry but also includes several interfaces to import measured 3D geometries. 3D Studio Max allows to develop a virtual scene in different ways, for example to add different lights, to generate viewpoints or to integrate sounds and so on. Also the so-called avatars – human beings in a virtual scene – may be created; realistic or with a lot of fantasy.

To expand the integrated features of VRML the external authoring interface (EAI) was developed. It is an external programming interface which allows to integrate JAVA-applets. With this tool it is possible to manipulate scenes and its objects.

An example is given in Figures 11 and 12. Figure 11 shows a part of Essen city with the Berliner Platz, which is going to be developed in the next few years. Figure 12 shows the same scene but with the integration of a possible masterplan. The future buildings may be faded in or out by a special Java-applet.

The presented technologies are very much suitable to create a 3D information system for global use in the world wide web. This is presently realized for the campus of Essen university. Various user groups like students, visitors, employees or administration will be able to get benefit from the system, being a knowledge database for information, planning but also marketing.

Seeing it from the technical point of view basic features of the system will be:

- Global availibility
- No additional costs for software purchase (browsers are free of charge)
- User-friendly interface

Fig 8a: Original digital image
Fig 8b: like 8a, but without distorsion
Fig 8c: like 8b, but rectified

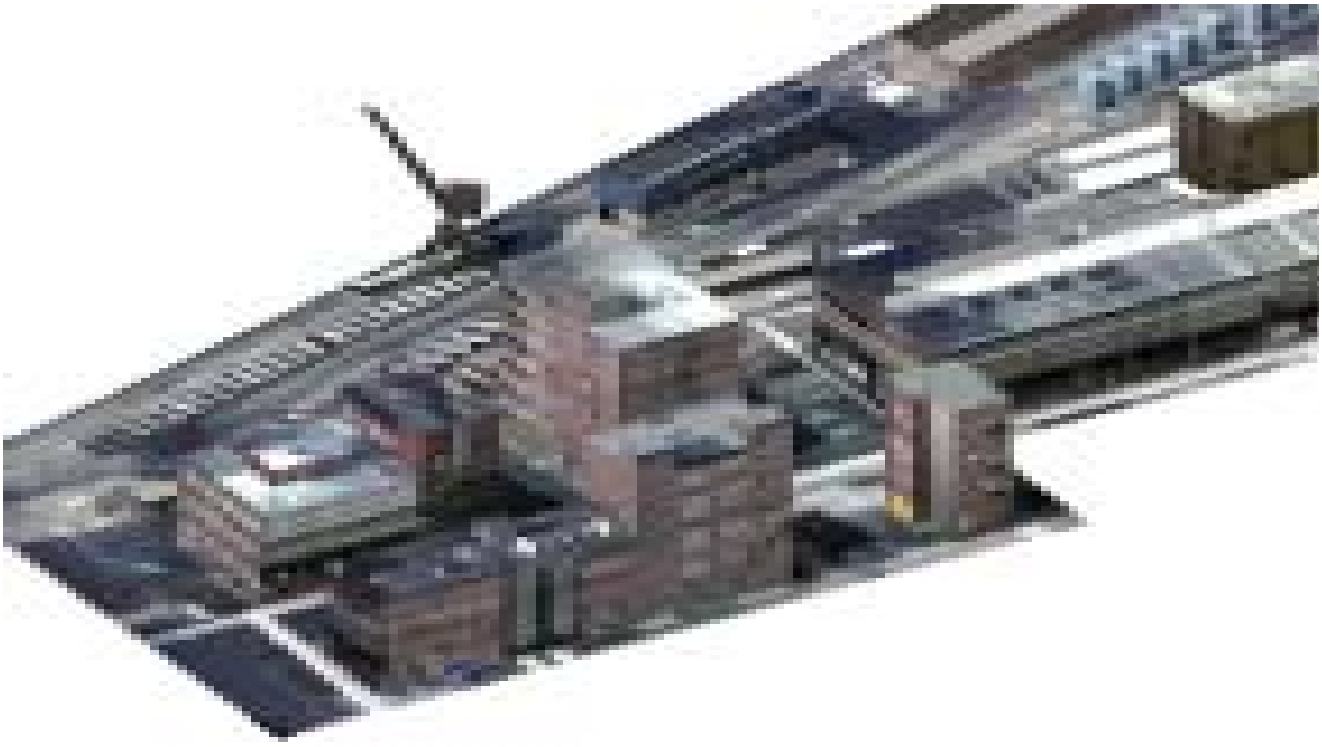


Fig 9: Photorealistic object modelling

Conclusion

The building of city models is a growing area of interest, many technical disciplines are involved in this theme. Photogrammetry is one of them, inte-grating a lot of positive features. The available informations given by digital ground cadastral maps can be integrated in an advantageous way. New and advanced software developments have to be done in this context. 3-dimensional city models, nowadays available for only some small areas, will be the basis of 3-dimensional applications and processes in the near future.

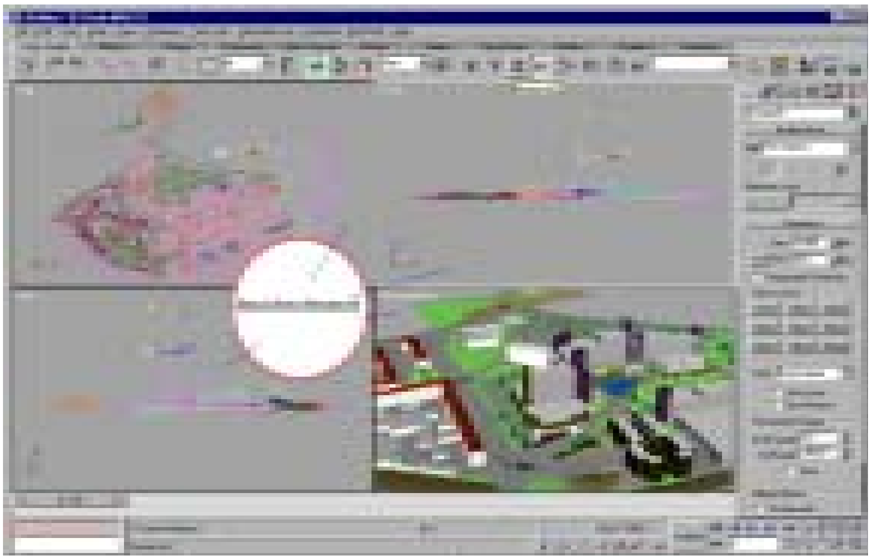


Fig 10: 3D Studio Max user interface

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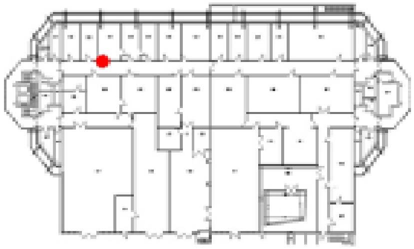
Fig 11: Berliner Platz at the present state www.essen-berliner-platz.de/fly/os// 0st.htm

Fig 12: Berliner Platz with future vision www.essen-berliner-platz.de/fly/ost/ 0st.htm



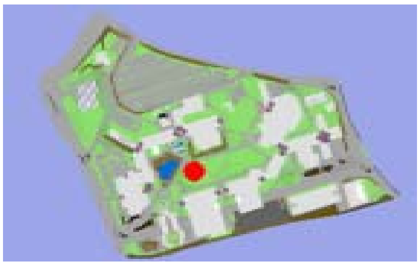


Fig 13 : Graphical elements of the campus information system

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