DIGITAL CLOSE RANGE PHOTOGRAMMETRY USING CAD AND RAYTRACING TECHNIQUES

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ABSTRACT

Digital methods have made their way also into close range applications. Beside the software and techniques that have been adopted from aerial photogrammetry new strategies for restitution and presentation of the digital data have been developed. The "Digital Projector" is a strict inverse photogrammetric approach that works without limitation for the object's shape and leads to a digital presentation with a lot of derivative results e.g. orthoimages and animations.

KURZFASSUNG

Zunehmend bedient sich auch die Nahbereichsphotogrammetrie digitaler Verfahren. Neben den aus der Luftbildmessung übernommenen Auswerteverfahren und -programmen sind neue Strategien für Auswertung und Darstellung in Entwicklung. Der "Digitale Projektor" ist ein strenger invers photogrammetrischer Ansatz, der ohne Beschränkung der Form eines Objekts auskommt und eine digitale Darstellung verwendet, die eine Vielzahl von abgeleiteten Ergebnissen (z.B. Orthobilder und Animationen) ermöglicht.

1. INTRODUCTION

Easy handling, the comfortable and clear processing with widely accessible computer equipment and all the advantage of low cost hard- and software have lead to an ultimate success of digital methods spread in all fields of photogrammetry today. The availability of digital images for close-range applications with Photo-CD and digital cameras as well as the valuable amount of data shows this field to be very suitable for digital photogrammetric solutions.

The classic results of e.g. architectural photogrammetry are facade maps. In addition to that, 3D grids, surface and volume models in connection with CAD systems come out of the spatial photogrammetric restitution. As in other surveying branches, the use of CAD systems has the advantage of easy continuation during the further data processing and administration.

Also the rectification of photographs is a wide-spread method in close range photogrammetry. Originally there have only been photos of planes to be rectified, later there also came up differential rectification of photos for even curved surfaces of objects. These approaches reached their limits as they all are restricted to surfaces of the form $z = f(x, y)$. This means that the third coordinate is only a (more or less) smooth mathematical function of x and y. No wonder, all these approaches came originally from aerial applications

I want to show the problem by an example. In generally it is impossible to describe architectural objects in the mentioned easy way because they contain ledges, alcoves and niches and hidden parts. Especially old buildings have very often rather irregular surfaces. Also a trivial partitioning into single facades even with curved surface will not always be possible.

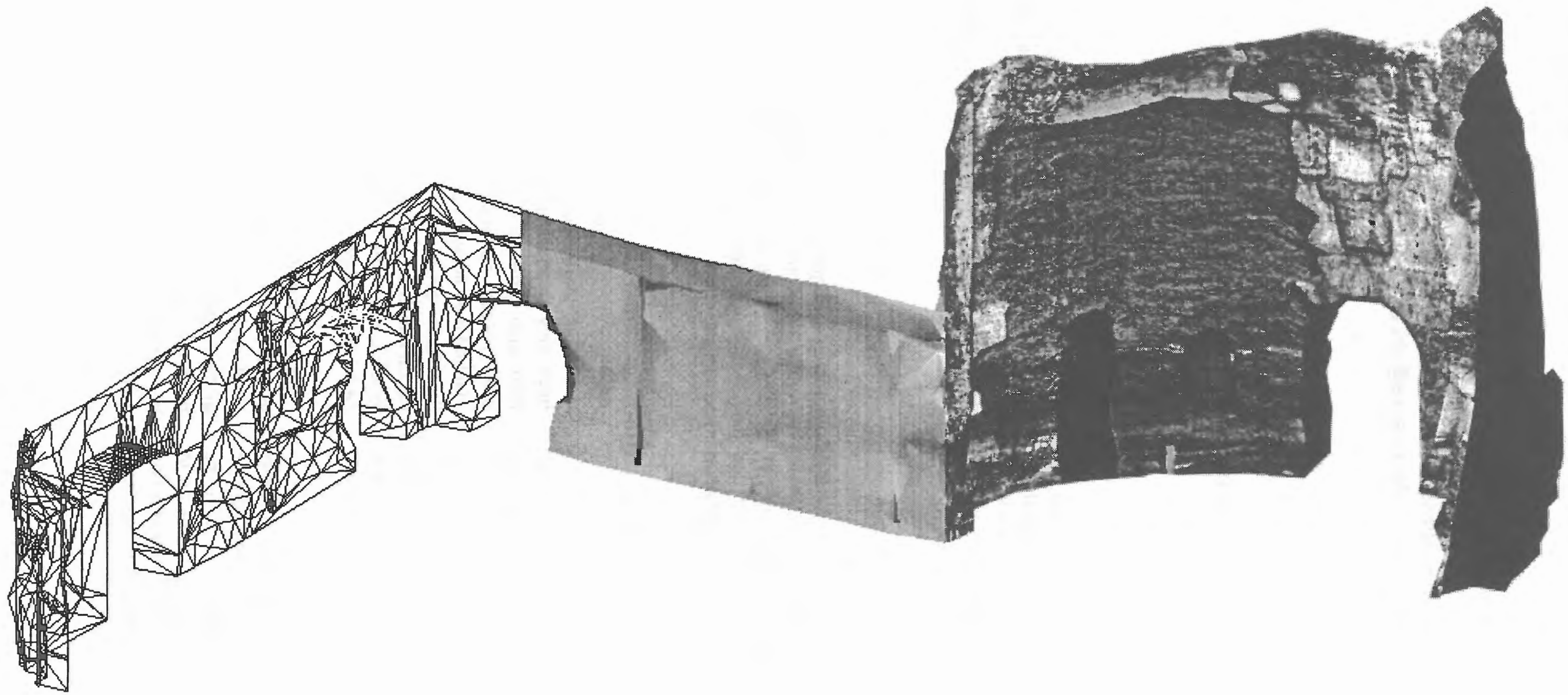

Figure 1: The steps during the creation of a virtual computer model

2. THE CONCEPT OF THE "DIGITAL PROJECTOR"

The concept of the "digital projector" approach is on one hand a new rigorous digital photogrammetric tool and on the other hand takes into account the demand for an object oriented, three-dimensional reconstruction of arbitrary objects in close-range applications.

On the contrary to the conventional "rectification" of metric photographs the "Digital Projector's" concept is a strict object oriented three-dimensional restitution of the whole object without almost any conditions and limitations. The approach is based on a consequent reversion of the situation during exposure.

The process of reconstruction of an object to get a virtual computer model happens in 3 individual steps (see Figure 1): In the first step the cameras inner geometry and its position and orientation during exposure as well as the objects' characteristic framework of outlines and faces is to be reconstructed. To get a homogenous solution of the total object these elements are computed in a photogrammetric bundle adjustment where a probable and reliable result of the whole measurement system is guaranteed. Beside of this way the restitution of the outlines may also come from an analytical plotter's result.

In the next step within a CAD environment this framework will be reviewed and if necessary completed where also additional measurements (photos, tape, theodolit, etc.) can be used. After that the 3D model will be closed defining faces between the structure lines and will be investigated for leakage performing a rendering process. The surface model that arise from that step will be used as a kind of "projection screen" and can be of a very different degree of details. In the third step happens the actual reprojection of the photos [Hanke, Ebrahim,1996].

Similar to a slide projector some selected photos are projected to the surface model using raytracing techniques. The selection of photos is regarding the visibility and direction of projection. The "Digital Projectors" use the same interior and exterior orientation as the related cameras. The therefore needed values result from the bundle adjustment. The output of this process is a complete 3D computer model of the object from which a number of further results can be derived later.

The approach is so general that it is not restricted to a certain type of e.g. architectural applications. As the restitution is strict object oriented there is no problem combining very different kinds of photos of the same object. The use of close shots for interesting details and overview shots to include neighboring objects with less resolution of projection is also possible without problems and shows the flexibility of the approach. It is also possible to combine the inner and outer parts of an object. In this case some of the projectors just have to be situated in the inner space and do the virtual projection onto the interior walls.

3. VISUALISATION, ANIMATION AND VRML

These 3D-photomodels are the source for all further derivatives e.g. parallel projections (orthoimages) (see Figure 2), perspective views (see Figure 3), arbitrary animations (fly-over and walk-around) or even interactive applications. It is up to the end user what kind of result he needs to achieve from the 3D model.

A new and very promising way to visualize 3D-data is to create "virtual worlds" not only for computer games but also for other "more serious" applications. The "Virtual Reality Modeling Language" (VRML) is a new standard format describing three-dimensional data in a way that they can be inspected interactively by the user [Vacca, 1996].

These models can so be viewed, turned around or anyhow animated in real-time even on a PC. Thus, VRML is suited to create e.g. interactive environments, internet museums, visualizations and simulations bases on real world data from arbitrary photogrammetric restitutions.

4. CONCLUSION

There is a fundamental change concerning the results of a surveying project. Following this development the 3D data will be administrated in structured information systems that do not anticipate any further use of this data. Plans and maps, perspective views or profiles and even virtual reality animations will be only derivative products of a coherent prepared database of the surveyed object. The way of using the derived data is not anticipated through this database. The kind of presentation (i.e. perspective or orthogonal view, global or any interesting detail, animation) will be decided by the end user of the data.

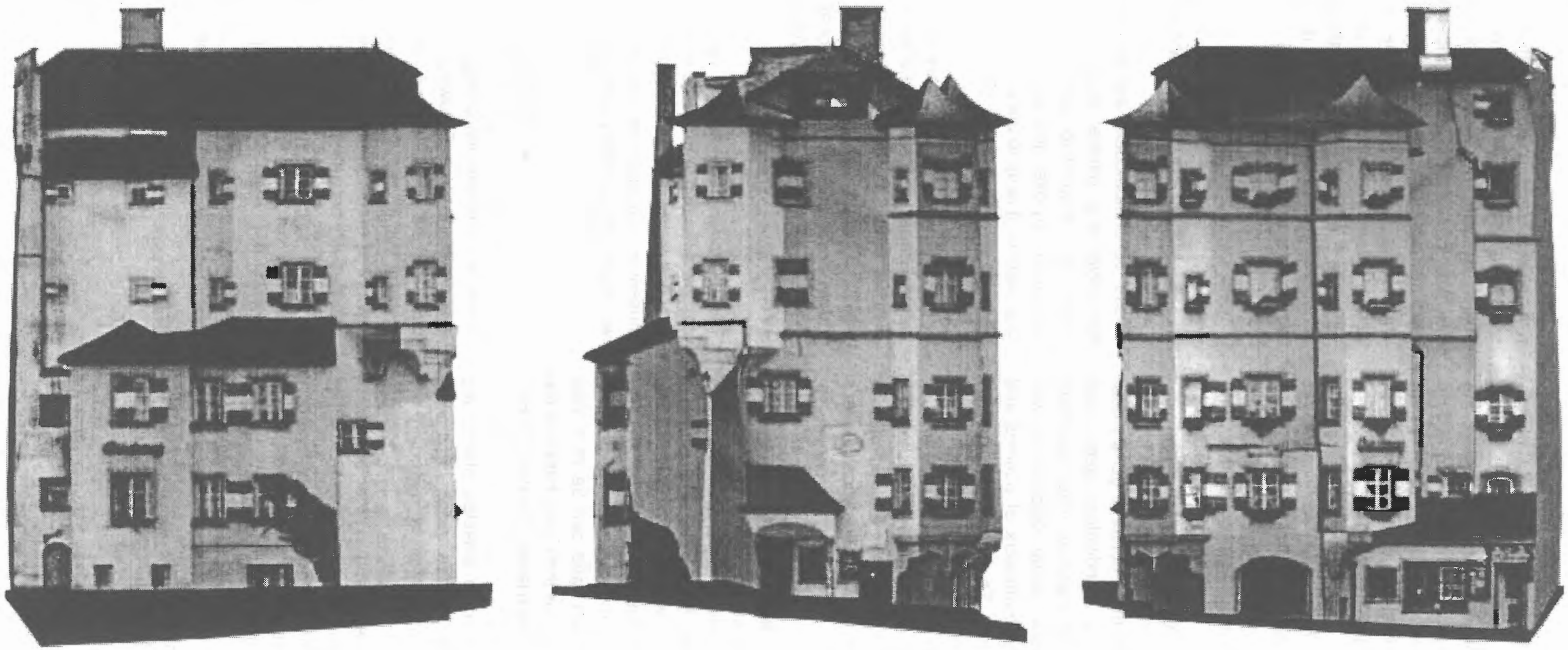

Figure 2: Orthoimages of 3 Facades of 3D-Model "Ottoburg", Innsbruck, Austria

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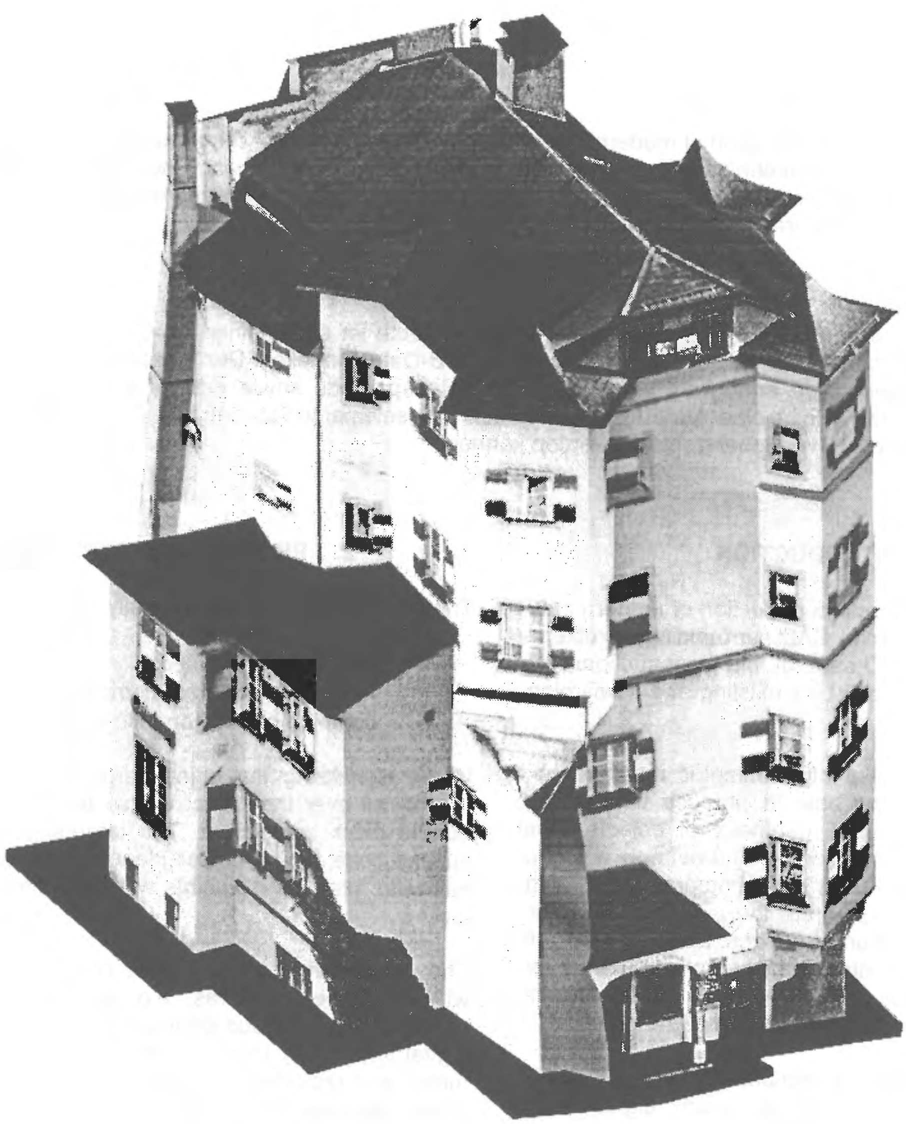

Figure 3: Perspective View of 3D-Model "Ottoburg", Innsbruck, Austria