3D Visualization of a Complex Cave System

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ABSTRACT: *Through an initiative of the Austrian Alpine Club (ÖAV) Cave Exploration Group in Schladming (Styria, Austria) the Institute for Cartography of the Dresden University of Technology surveyed the Dachstein Southface Cave, generally known as "The Dachstein Hole". In cooperation with the Visualization Group of the Computer Center of this university a digital visualization of this cave has been produced. The objective was to acquire 3D data and generate a 3D model and textures as a prerequisite for the creation a lifelike walk-through movie and a virtual reality model for interactive usage. The possibilities of the Visualization Group permitted to achieve satisfactory results by only using commercial software.*

Project Outline

The aim of the project was to digitally reproduce the cave and its surrounding Alpine panorama as close to real-life conditions as possible. Figure 1 shows a flow chart of the data processing.

The input data for the cave geometry model are measurements which were made during several expeditions. we purchased. the geometric model and the satellite image textures for the generation of the Alpine panorama. Photos of various cave passages served to produce textures of the interior of the cave. All the data together resulted in the complete 3D model. The data flow in Figure 1 goes from top to bottom.

Due to the combination of different data it was not possible to use one software program for the scene visualization. We decided in favour of the animation software of Softimage and the virtual reality program of Realax which comprehends a model-maker and real-time capabilities. Using these it is possible to realise a walk-through or fly-through. The same data served as a basis for the production of a video clip generated by means of Softimage. As equipment an SGI Onyx2 with 8 processors, one graphic pipe, stereo screen, shutter glasses and space mouse were at our disposal. An autostereoscopic display developed by the Department of Computer Science will furthermore be attached to this computer. A first "real 3D" overflight showing the Dachstein Alps has already been calculated for this display.

Surveying

The envisaged cave model, which was supposed to be as realistic as possible, required a high density of spatial data. In order to meet these high demands and to keep the effort within justifiable limits, the measurements of the cross-sections of the cave passages have been performed in such a way, that the characteristic shape is recorded as complete as possible, and to get it with a minimum number of cross-sections. This is why the cross-sections are notlocated in defined distances to the fixed reference points but according to the shape characteristics of the cave. Hence, portions with more dynamic profile characteristics, i.e. frequent chances in shape, are described by narrower cross-sections. Uniform or regular, tunnel-like corridors, on the other hand, require only a low density.

For the measuring of the cross-sections the polygon segments of the basic survey have to be reconstructed by physical or optical measurements of the respective fixed point. In general, the profiles have been surveyed orthogonally to the polygon axis. Basically the cross-sections consist of eight measurements in well-defined directions with a constant angular interval of 45 degrees.

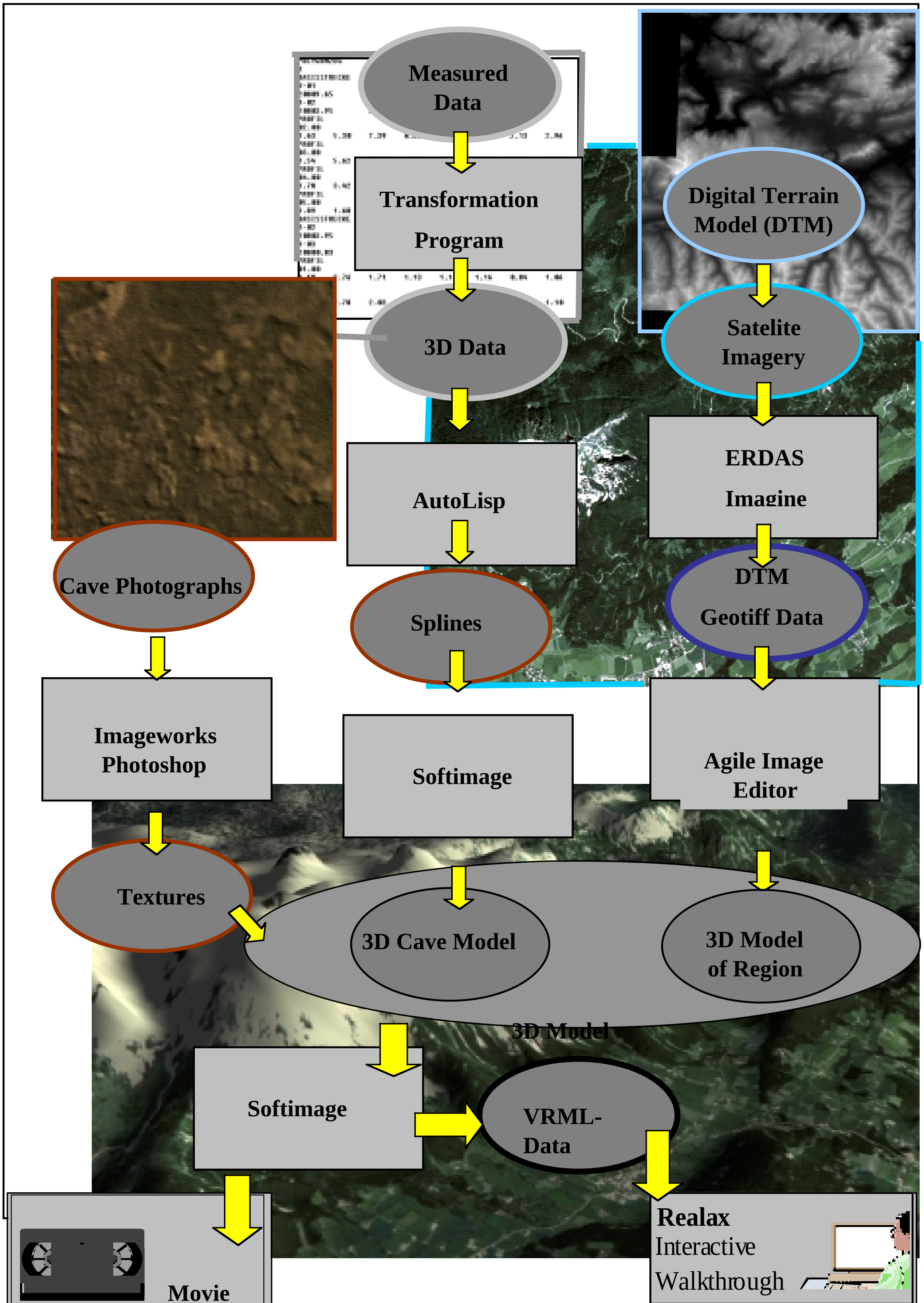
Measured Data
Transformation Program
3D Data
Digital Terrain Model (DTM)
Satelite Imagery
ERDAS Imagine
DTM Geotiff Data
Agile Image Editor
AutoLisp
Splines
Softimage
Cave Photographs
Imageworks Photoshop
Textures
3D Cave Model
3D Model of Region
3D Model
Softimage
VRML-Data
Movie
Realax
Interactive
Walkthrough

Figure 1. Flow chart of data processing

The cave measurements resulted in charts, containing the polygon point numbers with the corresponding Gauss-Krueger Coordinates and the cross-section data of eight defined directions in the form of distance measurements between the cross- section base point and the respective cave wall points. In addition, the distance of the section from the last polygon reference point was also recorded (cf. Figure 2).

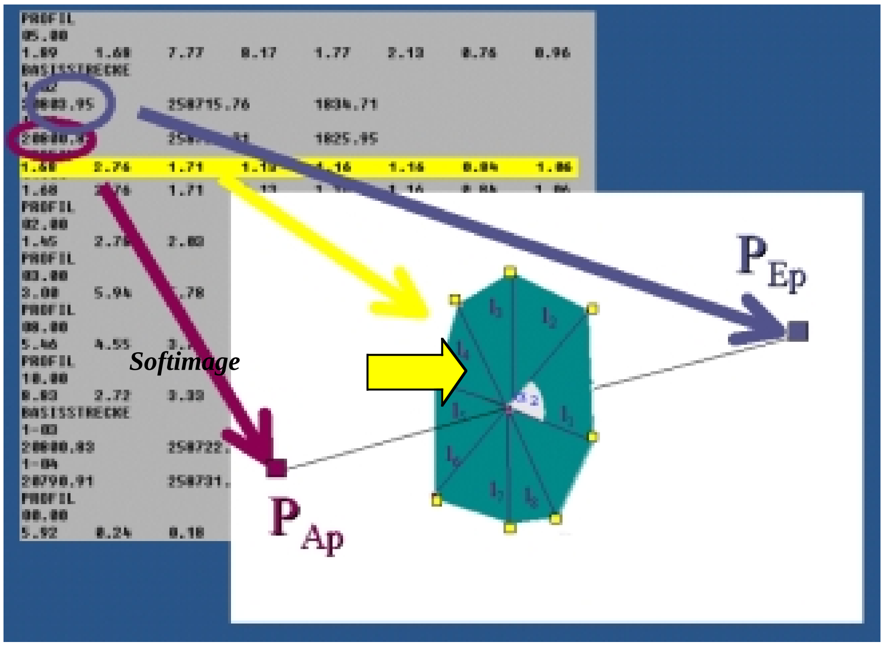

Figure 2. Results of cave measurements

Data Transformation and Mapping

Cave Data

The recorded values were transferred into an ASCII-file in a specially developed format. Out of this file the necessary data can be extracted and transformed into the required program-specific form for further processing. This file contains 3D points which must then be integrated into a network. The data transformation is principally performed in three steps. First the contours of the measured profiles are calculated in a model coordinate system. Subsequently the transformation of the corresponding polygon portion from the Austrian national coordinate system was carried out, simultaneously shifting the starting point of this portion into the coordinate origin.

The resulting azimuth and elevation angles of the cross-section basis allow the rotation of the individual points into the model space corresponding to the center position of the intersection point with the respective polygon portion (cf. Figure 3). These model coordinates are then converted into the coordinates of the Austrian National Survey by shifting the base and profile points (cf. Figure 4).

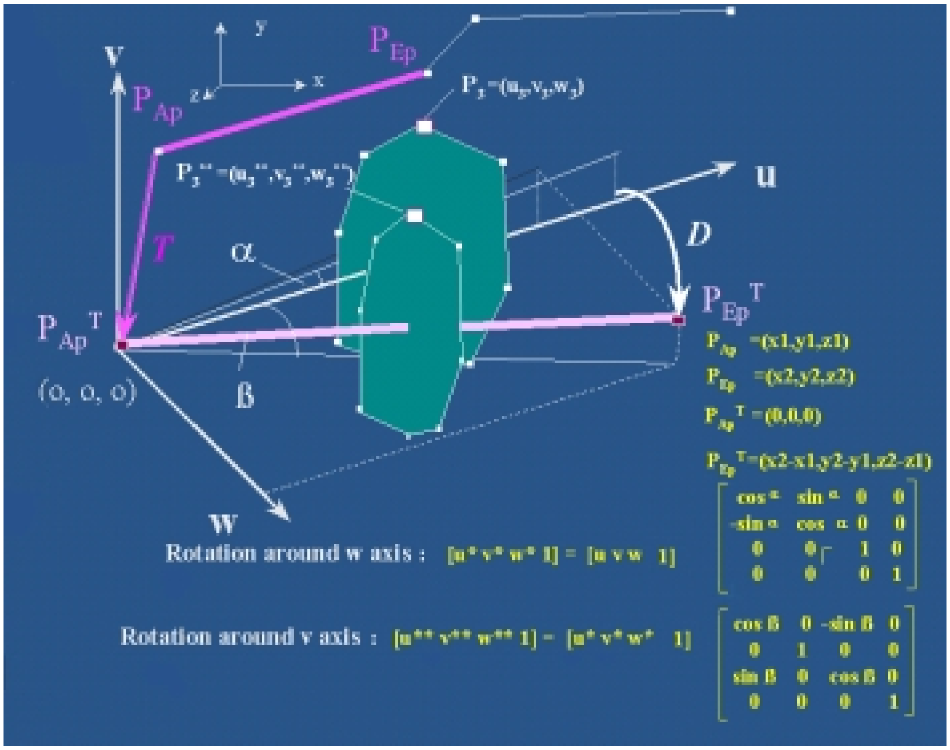

Figure 3. Rotation of cross-section points with respect to the intersection point with the respective polygon portion

The cave geometry has been generated using splines. This was done with a small AutoLisp program. Splines permit the use of a bump mapping method. Using Softimage the resulting points can be integrated into a network in different ways. So, for example, surfaces can be crumpled up or facetted, i.e. substituted by more detailed polygons which are then integrated into the network. In both cases, however, this involves a deformation of the model. Figure 4 shows a composite representation of the entrance area of the Dachstein Southface Cave. The length of the represented passage is approx. 40 m and the total height 30 m. The corresponding model consists of approximately 2 600 triangles.

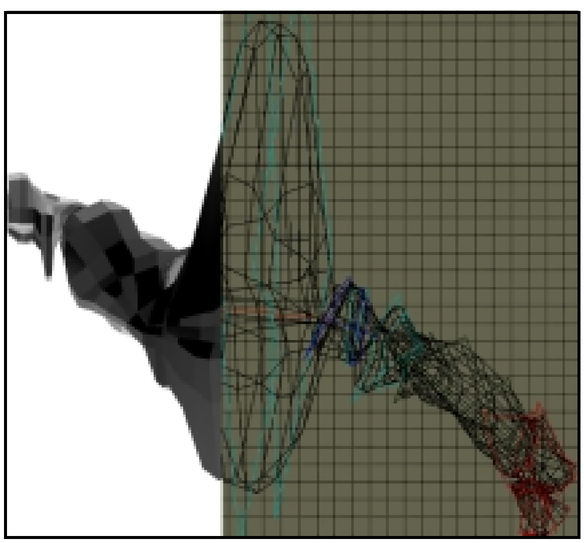

Figure 4. Split representation of hidden surface and wireframe model of the entrance area of the cave

Data of Alpine Surrounding

The geometry data of the Dachstein Region were generated using the Agile Image Editor program. By means of this program it is possible to change the height information contained in Geotiff data into geometry, resulting in a file in VRML format. The calculated model consists of approx. 130 500 triangles (cf. Figure 5). In a next step the cave model will be inserted into the digital terrain model covered by the Dachstein Massif satellite ortho-imagery, in order to put the it into a precise geographic context.

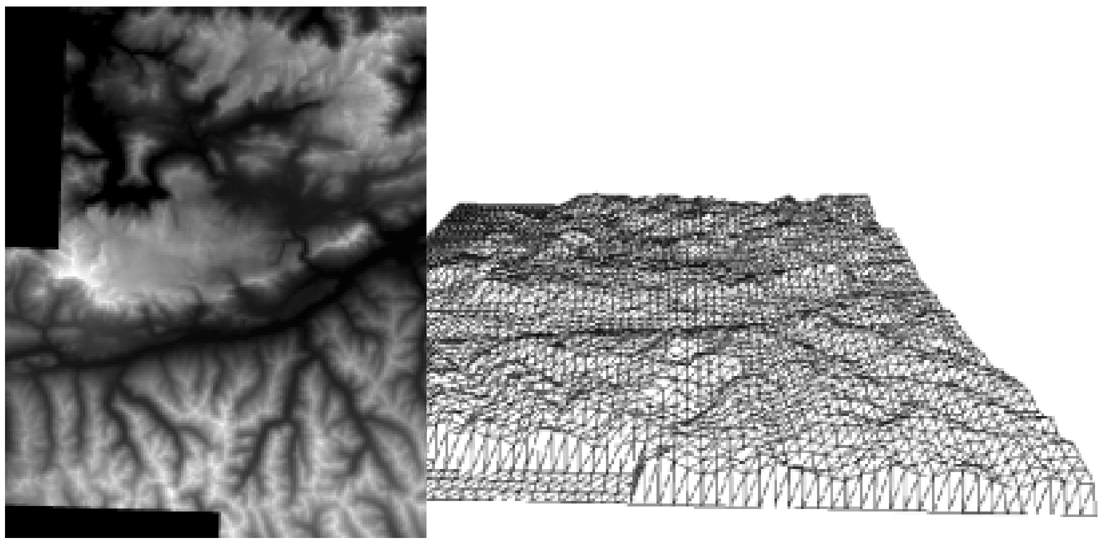

Figure 5. Geotiff data of the DTM and triangulated regular network (TIN) of the Dachstein Region

Interim Review and Further Activities

The 3D visualization of the Dachstein Southface cave allows a much more comprehensible representation of all geometric characteristics and, thus, facilitates the planning of future advances into unexplored parts of the cave and other geoscientific research in the portions already known. The resulting photo-realistic 3D representation of the cave (cf. Figure 6) serves as a basis for further investigations by spelaeologists, geologists and hydrologists.

Acknowledgements

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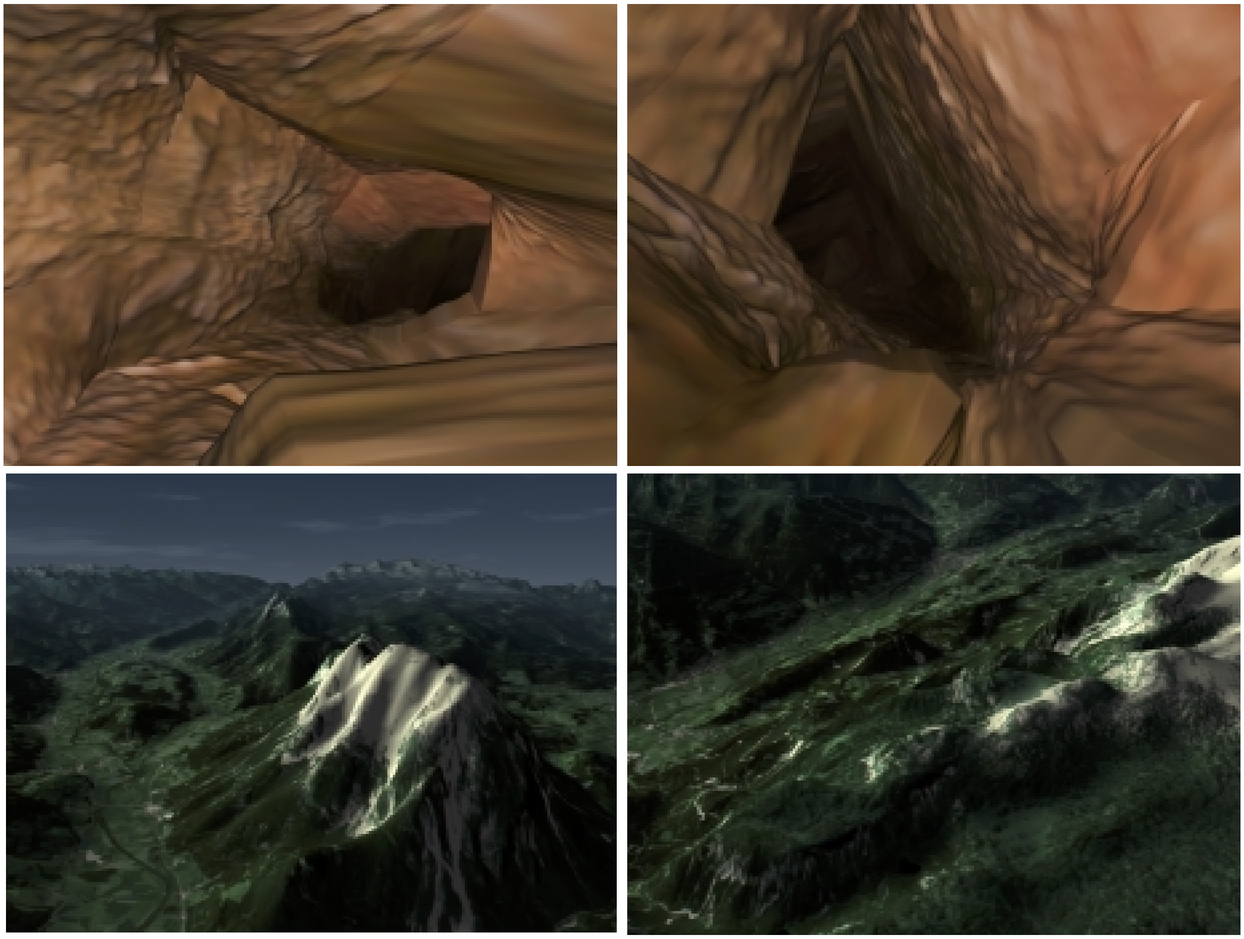

Figure 6. Some results. Above: Views of the interior of the cave. Below: Views of the Dachstein region

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