Subterranean-Modelling

From plan to computer model - Entering the 3rd dimension

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The German Mining Museum is mainly working on the exploration and examination of ancient mining. There for it is important that a precise map is drawn up where the results of e.g. an excavation or the ancient working traces are documented. Sometimes there is already a 2D plan and one wants to "add" or improve more information to the plan. Very soon a plan becomes confusing e.g. when passages intersect on different levels or (interesting) parts are hidden by others in the respective projection.
In this article possible workflows will be shown, starting with the measuring of cross sections with various equipment (optical, electro optical). Further more different possibilities of how to orientate the single sections are discussed and the construction of the 3D model is revealed by using AutoCAD and 3D Studio MAX

Subterranean measurement, respectively subterranean documentation is a very special and difficult topic, which is to be handled of course with special (technical-) solutions. The very detailed requirements are pointed out and (our) solutions are described.

In mining archaeology it is often not enough to record the „object" (mine) *itself*, but also the excavation inside the „object". All these objects like graves, cellars, caves and mines, do not only reveal their information on the ground but also at the side-walls and at the roof ridge. These irregular (surface) structures can not always be simplified in a plane (ground plan, section plan, etc.) therefore it is necessary to keep the information e.g. in a 3D model. The advantages of having a computer model in addition to photos, videos and plans must not be pointed out separately, but in mining archaeology you finally get the possibility of:

- calculating the volume (how much material was extracted)
- looking at your model from outside ("through the rock")
- constructing any section you wish
- preserving the information of roof, walls and ground in *one* "plan"

Having come to the conclusion to document your object-structure, 3-dimensionaly, you must decide how the data is to be captured. Beside the well known and often used "laser scanning", we are glad to present an alternative method, the so called "profile scanning".

The measuring of cross sections is suitable wherever you work in small spaces (e.g. between two walls) or in stretched structures like galleries. There are two main methods of measuring cross sections

1. an optical one[1]
2. an electro-optical one.

The optical method is operating by taking pictures of a light-bar emitted with a flashlight. The light-bar is an app. 5cm width shape covering the walls (fig. 2).

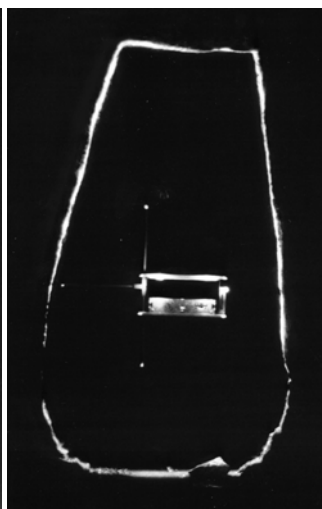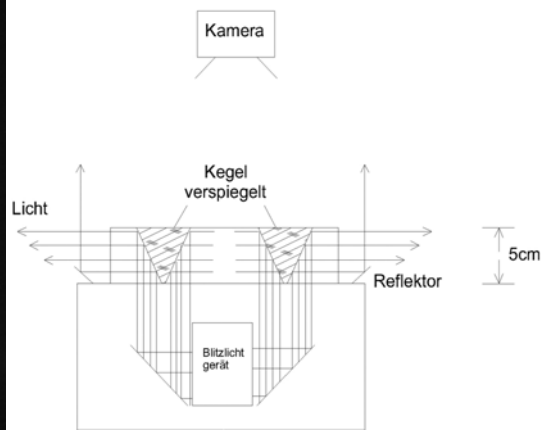fig. 1 orig. picture   fig. 2   cross section   fig. 3   flashlight device

The little light spots next to the device (visible in the second picture) are put up in a known distance, giving the scale while digitising the photo.

There are several limitations to observe using this method. e.g. you always have to get far away enough from the cross section to take a picture of it, which can be limited by the available space and the focal length of your camera. This is the reason why (and because of other limitations) the Deutsches Bergbau-Museum Bochum in association with partners from speleologie[2] has developed a device which measures a cross section electro optically.

fig. 4 Laser scanning device

The frequency of the laser is 100 Hz. During 3 seconds the laser rotates about 360° with the result that a single cross section consists of 300 vertices.

The data is sent to a Palm IIIe handheld device where it is calculated and displayed. The user is now able to check the scan for errors, caused by e.g. less reflection or invisible parts of the section.

fig. 5 Palm input screen

fig. 6 Palm control screen

fig. 7 measurement in an ancient mine

To built up a 3D model you need the position where each cross section was captured. Therefore a measuring tape is put between two polygon points with known coordinates during the measurement. The particular position (read off the tape) of taking the scan is manually input into the palm device (fig. 5). Holding the scanner-device horizontally and parallel next to the tape the scan is started and 3 seconds later the cross section is displayed on the Palm.

After transferring the data to a PC, the computer can put the shape *nearly* in the right position in (virtual) 3D space. *Nearly*, because you slightly hav

e to adjust the horizontal and vertical position. This is because you may not always have put the profile scanner right next to the tape, but due to local circumstances differed from this specification (but you *always* have to put up the device horizontally and parallel to the tape).

The following figures show the recorded data first being reduced from 300 points to app. 30 points. The reduction of the data is very important to keep the amount of polygons of your 3D model as low as possible, and thus manageable. Second the spline has to be smoothed which gives the structure a much more natural appearance and also eliminates "jumps" between two vertices caused by the measurement error of the laser scanner. As you can see in fig. 8, the tape, which was put between two polygon points, can be identified as a peak in the blue shape. You also see the vertical and horizontal offset of the measuring tape "connecting" the point of origin of the profile scanner with the tape.
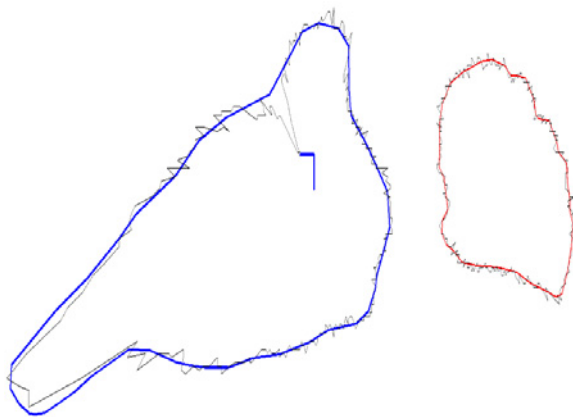

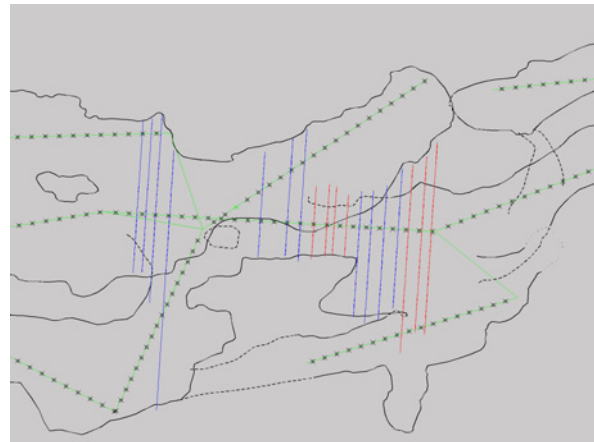fig. 8 point reduction, smoothing and localisation of the tape

fig. 9 arranging the shapes with the help of a ground plan in AutoCAD

After positioning the shapes in 3D space in Auto CAD, we export the complete data set to 3D Studio MAX. A mesh is constructed based on all the single shapes. Taking measurements e.g. every 30 cm provides the opportunity to built up a very detailed 3D model. Adding textures and lights to the wire frame model, you can arrange an almost photo realistic 3D computer model.
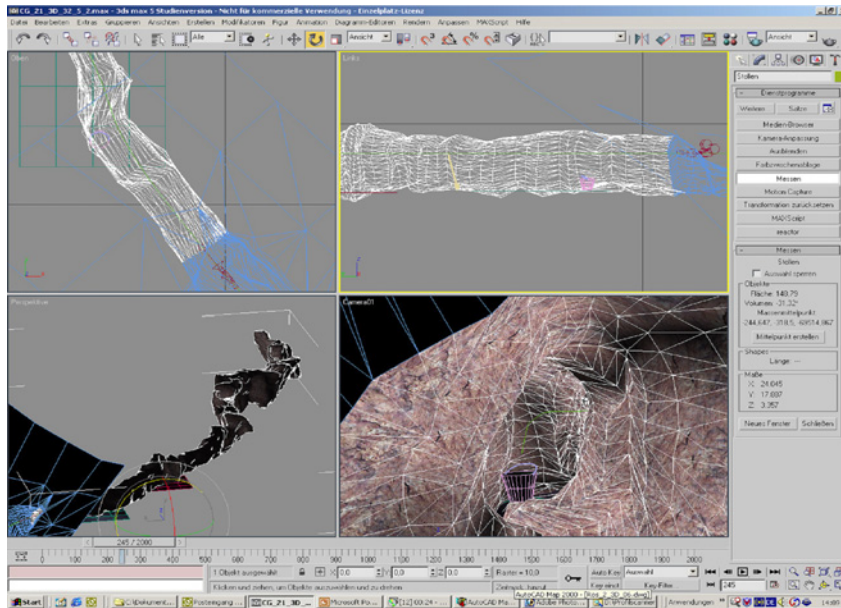
fig. 10 screenshot of a model of a mine in 3D Studio MAX

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[1] This optical light section device was developed and built in the Deutsches Bergbau-Museum in the early 80´s.

[2] Martin Melzer (Switzerland) from the HFG Karlsruhe did the programming of the Software for the Palm device and he developed the control unit. Martin Heller (Switzerland) has programmed the tool for converting the Palm –data to an AutoCAD readable dxf file.