# SCOP AS AN ALL-PURPOSED TOOL FOR ELABORATION OF DIGITAL TERRAIN MODEL - THE USER'S COMMENTS

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Commission IV, Working group 4

**KEY WORDS :** DEM/DTM, GIS, Digitization, Orthoimage, Acqiusition, Modeling

## ABSTRACT

Depending on the scale, scope and kind of problems solved by the spatial information system (GIS,LIS) they need to be supported by DTM with different degree of accuracy and minuteness of detail.
The quality and accuracy of DTM depend on the data-acquisition and the mathematical technique of interpolation. In this paper, the acquirements with different projects, which purpose was a description of the surface of the earth as well as another objects, will be presented. These experiences were carried out in 1993-96, thanks to supplying us with the SCOP package within the framework of Central European Initiative (CEI).

## 1. INTRODUCTION

Since mid 1993 the Department of Photogrammetry and Remote Sensing Informatics at AGH has got the specialistic SCOP (Stuttgart COntour Programme) package. The package is a result of many years long experiments carried out by researchers at Stuttgart and Vienna Universities. It has been continuously modernised and developed.
It is indispensable in GIS systems to have information about the surface relief. The most popular forms of representation of the terrain topography are isolines or regular grids. The grid form, is more applicable because it gives possibilities for 3-D space analyses and is necessary for ortho-rectification of aerial or satellite images.
The source of data for DTM creation can be different, but most often the data are collected from topographic maps or aerial photographs. The choose of data source and the method of their digitization depends on many factors as:
- data accessibility;
- required accuracy;
- time and costs of production.

In the last 2 years the Department of Photogrammetry and Remote Sensing Informatics accomplished several projects related to creation of a DTM. In each of the projects the SCOP was used to create DTM independently from data acquirement method.

In the paper, the authors present the way of such data preparation for reliable SCOP interpolation avoiding impact of big differences in data density.

## 2. DATA ACQUISITION

The accuracy of DTM is strongly related to the method of data acquisition. Direct geodetic survey is the source of the most accurate hights information. A competitive method, especially from the viewpoint of economy, is photogrammetric survey.
When accuracy requirements are low then digitization of the existing cartographic maps is a relatively cheap and fast method for data acquisition. The latter method is widely used in data collecting for Geographical Information Systems ( GIS ).
In our projects we have applied various methods of data acquisition: direct digitization of topographic maps, digitization of scanned maps, stereo-digitization of aerial photographs, and direct field measurements with use of a total station. The variety of these methods is presented in Table 1, which contain short characteristic of some projects.

## 3. MATHEMATICAL MODEL OF INTERPOLATION

In each projects shown in Table 1, the SCOP was used to create DTM. In comparison with other programs in the field of DTM, the SCOP has some particular features, among others:
- four categories of points are taken into consideration in the interpolation process: dispersed points, spot heights, sequences of points that create the form lines, and break lines,
- the possibility to assign different accuracy to data allows for interpolation with filtration.

The SCOP reliably models the terrain relief in those cases where the data are obtained along profile lines supplemented with the structural lines. It is interesting that the SCOP program is easier to use for mountainous and wavy terrains than for the plane ones. In the latter case it requires a significantly higher density of data than it can be obtained from contour line digitization.

The effects of SCOP interpolation are not stable in areas of different density of data. This occurs especially in places where the flat terrain transits into elevated surface.
The linear prediction method was used to interpolate the DTM points. This method is reliable to cope even with the most complicated surfaces including the elements of their discontinuity. However, the calculation parameters should be choosen with caution and data have to be properly prepared. For proper interpolation program requires similar data density for the whole area, what in many cases is difficult to achieve.

Table 1.

**List of projects realized by Dept. of Photogrammetry and Remote Sensing AGH Kraków**

| Project name | Area of interest | Source and method of data acquirement | Data Number of points ( Number of points in break-lines ) | Grid size in SCOP | Final result |
|---|---|---|---|---|---|
| KRAKÓW | 40 km x 40 km | topographical map 1:50000 contour digitization | 43 000 (1000) | 30 x 30 m | grid 30m x 30m |
| SKAŁA | 1 km x 1.6 km | polar method with use of Total Station | 10 500 (1500) | 2.5m x 2.5m | contours |
| ŁAZY | 25 km x 6 km | topographical map 1:10000 scanning, raster-vector conversion, digitization on screen | 300 000 (26 000) | 10m x 10m | grid 5m x 5m |
| KONIN | 12 km x 5 km | topograph.maps 1:1000 & 1:10000 scanning, raster-vector conversion, digitization on screen | 120 000 (13 600) | 2m x 2m | grid for orthophoto rectification |
| | | aerial photos 1:8000 manual profile measurement on stereo-plotter Stereometrograph with automatic recording | 100 000 (10 000) | 2m x 2m | enhancement of DTM for contour map in scale 1:2000 |
| RABA | 700 $km^2$ | topograph.maps 1:10000 scanning, raster-vector conversion, digitization on screen | 1000 000 (215 000) | 10m x 10m | grid 10 x 10 m |
| | | aerial photos 1:30000 manual profile measurement on stereo-plotter Stereometrograph with automatic recording | 100 000 (50 000) | 10m x 10m | |
| WAWEL (surface of historical wall-painting) | 2.5m x 5m | manual measurement with micrometer | 5000 (400) | 5cm x 5cm | grid 5cm x 5cm |

## 4. PREPARATION OF MAP-DIGITIZED DATA IN ORDER TO CALCULATE DTM

The SCOP was mainly designed to create the DTM from photogrammetric measurement. So, in cases, when data are derived by digitization of map contour lines, the problem of different density of data often occurs - for sloped surface the density of contours is high, while for a flat terrain the density is low (assuming that the contour line interval is the same).
Interpolation with linear prediction method causes undesirable effects in places with differential data density - interpolated surface may get unreal depressions or overhights. In such case good results could be reached by division the region, using break-lines, into smaller sub-regions according to the data density. Such situation is shown in Fig.1. When a default method of interpolation is used, the SCOP adjust the way of calculation to data type: calculation units with break-lines are computing with linear function, while for units without break-lines the bell-curve function is applied. The thick lines in Fig.1. are not in fact the terrain (authentic) break-lines, but when we give them such attribute, surface modelling in SCOP would be more correct.

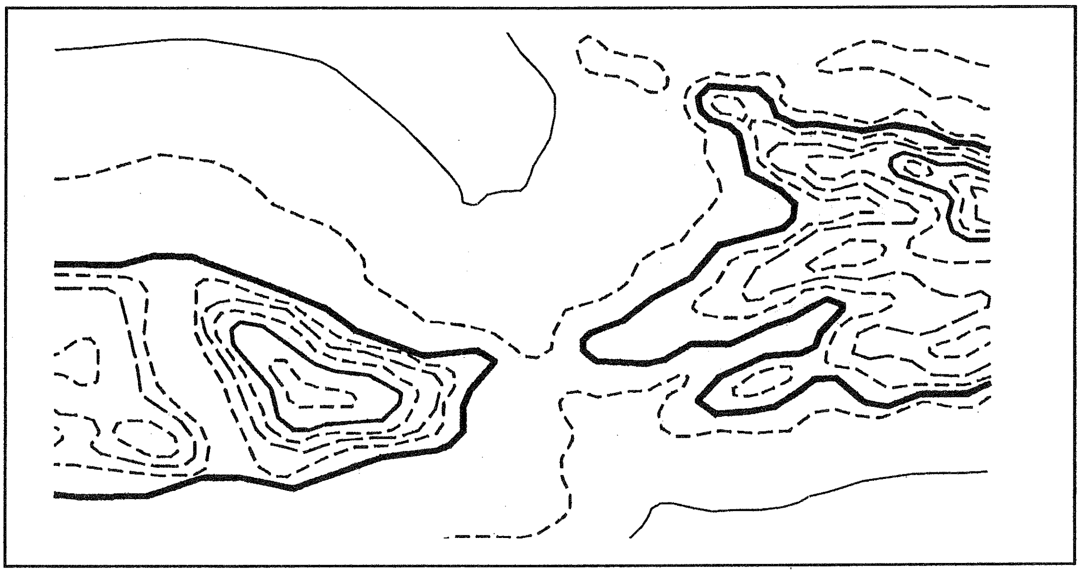

Fig.1. Example of division the region with different density of the data points for proper DTM modelling using not authentic break lines

## 5. SCOP AS A TOOL FOR DATA VERIFICATION

Problem of gross errors in data especially concern the creation of DTM on the ground of isolines' digitization. Transformation of isoline drawing from 2D to 3D space requires manual typing of hights attributes. It is the reason that the gross errors can be easely done.

The SCOP has a possibility of surface interpolation with various filtering of data. This attribute of program is used to search for errors. The first run of the calculation of a terrain model is performed with such parameters, which gives effect of a strong smoothing of surface. Differences between hights of calculated surface and hights of data are basis for localization of gross errors. Example of finding out an error in data is shown in Fig.2.

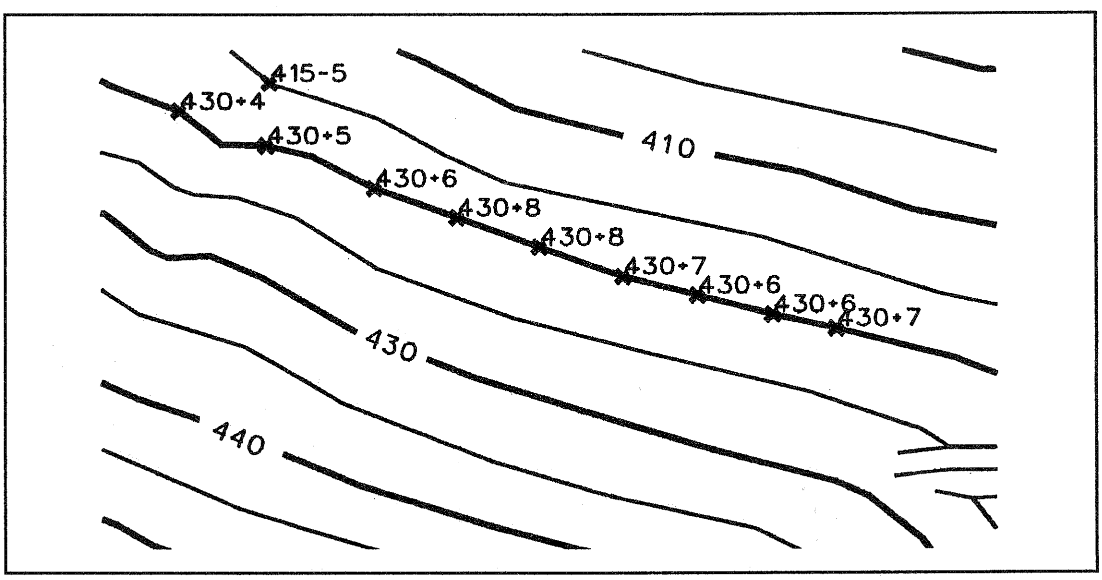


Fig.2. The result of gross errors detection - the marked contour line have by mistake the hight 430m instead of 420m

## 6. THE USE OF SCOP PRODUCTS IN OTHER APPLICATIONS

We treated SCOP system like a professional, flexible tool for solving the most of classical tasks of DTM creation. Although we dispose of another software applications for this problem (SURFER, MGE Terrain Analyst), after all SCOP is superior to them because of it's interpolation quality. Therefore we always use that system to calculate DTM in the form of grid. On the other hand later we export such grid to another systems. Procedures applied by us are shown in Fig.3.

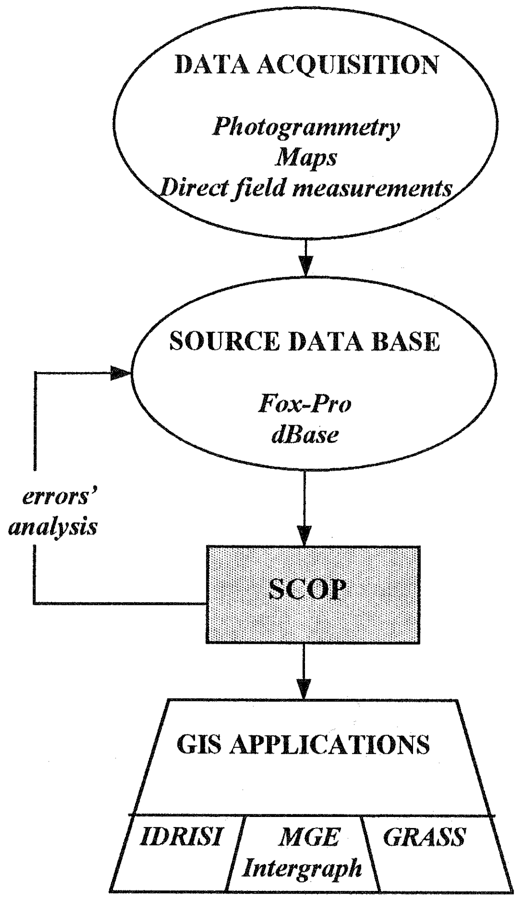


Fig.3. Creation and application of DTM

## CONCLUSIONS

System SCOP is successfully employed in many institutions, mostly in Europe. In last five years, thanks to CEI initiative, few countries of eastern Europe joined the group of SCOP users.

Many of GIS tools have got functions to execute DTM tasks. However they are rather adapted to realize various analyses with terrain model, than to create it. Therefore specialistic tools for different tasks are needed, such, for example, SCOP for DTM calculation.

Products of SCOP can be successfully imported to GIS systems, like: IDRISI, ERDAS, GRASS, MGE Intergraph.

In Fig.4. orthophoto image draping over grid in perspectives view - example of integration between systems SCOP and GRASS is shown.

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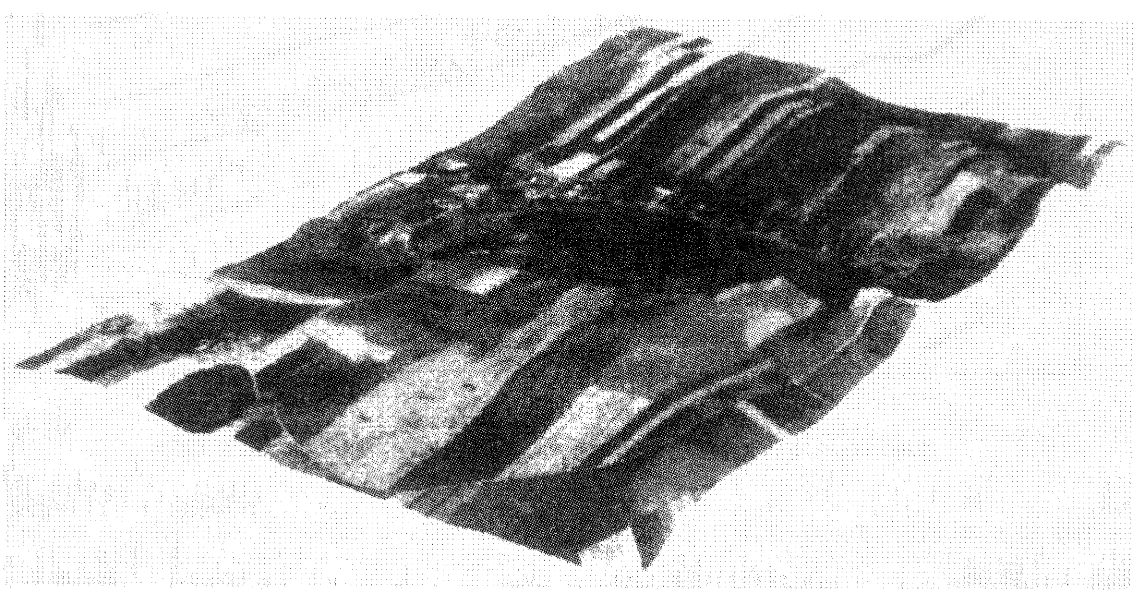

Fig.4. The orthophotoimage draped over grid in perspective view