AUTOMATIC GENERATION OF DIGITAL ELEVATION MODELS USING PYTHON SCRIPTS

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ABSTRACT

The ArcGIS software from ESRI contains tools for interpolation of raster surfaces from point data. There are four classical interpolation methods: IDW, spline with tension, regularized spline, and kriging in the "3D analysis" toolbox in the "Interpolation method" toolset in the ArcCatalog application. It is possible to set different parameter values for each interpolation method in ArcGIS. These parameter settings influence the output digital elevation models. The research team in the Department of Geoinformatics, Palacký University in Olomouc, needed test datasets containing various DEMs for statistical evaluation. The aim of this research was to find suitable interpolation methods and combinations of parameters for various types of georelief using the widely accessible interpolation methods in ArcGIS.

A new application called "DEM_Testing" for automatic creation of various digital elevation models was created in the Python language. The application consists of two Python scripts. The first script automatically creates DEMs, and the second creates raster files with morphometric characteristics for all previously created test DEMs. These scripts have proven to be very helpful in the stage of creating test data. The purpose, functionality, structure, and use of these scripts are presented in this article.

Keywords: ArcGIS, geoprocessor, interpolation method, scripting, Python language

INTRODUCTION

There are several ways how to utilize any tool in ArcGIS. This first is one time interactive run of tool with setting parameters in ArcCatalog. The second method is using command line also for one time run of tool. The third method is a creation of model in ModelBuilder. The fourth possibility is scripting in Python language. Python script is the best for batch processing. The scripting in Python language is suitable for processing of a large amount of data.

Programming is a good way to extend the functionality in ArcGIS software. The scripting in the Python language has one disadvantage. It is no definition of the special window interface with menus, option buttons, combo boxes, check buttons, pictures, etc. Interface of Python script only allows setting of input parameters as names of the layers, names of directories, workspace, attributes and text and numeral parameters. The other way to extend the functionality is the creation of an application interface (API) based on ArcObjects. The basic functionality of ArcObjects can be accessed using four APIs: COM, .NET, Java, and C++. An API advantage is that there is a dialog window definition for setting options in these scripting languages. Example of practical extension based on API and ArcObject was described in [1]. It is extension "*Diagram*

map creator". Utilization of extension was aimed for better and automatic creation diagrams in the thematic diagram maps.

INTERPOLATION IN ARCGIS AND TESTING DATA

DEM is possible create form several type of dataset. The newest way is using of LIDAR data [2]. Simple dataset is group of elevation point. Software ArcGIS from ESRI has tools for interpolation of raster surface from point data. There are four classical interpolation methods: IDW, Spline with tension, Regularised spline and Kriging in "*3D analysis*" toolbox under "*Interpolation method*" toolset in application ArcCatalog. It is possible to set different values of parameters for each interpolation method in ArcGIS. Setting of parameters has influence on the output digital elevation models. Research team on Department of Geoinformatics needed testing datasets of various DEMs for statistical evaluation. The aim was to find suitable interpolation method and suitable combination of parameters for different type of georelief by utilization all accessible interpolation method in ArcGIS.

Research was aimed to compare interpolation methods for 20 various training areas. Trial areas are selected in order to cover varying types of relief: wakes plains, flat and rugged wold, flat and rugged highland and flat and rugged hilliness. The next criteria for selecting the trial testing areas was well balanced representation of both main geomorphological systems in the Czech Republic - Karpaty and Hercyny [3]. The size of every area was 4 x 4 km. The base data was 20 point feature classes in SHP format for ArcGIS. The various digital elevation models were created by Python script for all these 20 training areas.

SCRIPTING IN PYTHON AND GEOPROCESSOR

Starting point was a simple model in ModelBuilder with four interpolation tools from ArcToolbox. ModelBuilder belongs to visual programming languages (VPL). Visual programming language is very quick way to built data workflow [4]. Afterwards, the simple starting model in ModelBuilder was changed to a parameter model and automatically converted to Python script.

There are more ways for adaptation of programming code according special requirement in Python script. Scripting in Python was the best for our purpose. Python language was chosen for creation of testing datasets of DEM. Manual running every interpolation methods with various parameters was very time consuming for 20 different areas. Scripting in Python is very good supported by ESRI. Our experience with scripting in Python was also the reason for this decision.

Scripting in Python has several advantages. Script can call all tools from ArcCatalog and other methods from object Geoprocessor. The interpolation method IDW, Spline and Kriging are tools from ArcCatalog. Geoprocessor has a group of enumeration methods that return Python list of all file names in the directory on hard disk. The enumeration methods are only accessible by scripting. They are not accessible from ArcCatalog. One of enumeration methods of Geoprocessor named ListRasters was used in the script. All methods are documented in Geoprocessor model [5] and manual [6]. It is also possible work with text files in Python scripts – read from a text file and write to a text file. Text files were used for input of parameters for interpolation methods. All

advantages: calling tools, calling geoprocessor methods and reading from text files were implemented in designed scripts.

DESCRIPTION OF THE APPLICATION

The application "DEM_Testing" is used as user added toolbox in ArcCatalog. The user toolbox "DEM_Testing" consists of two scripts (Fig. 1). The first script runs four interpolation methods for one input point layer. The second script calculates morphometric characteristics: a slope, an aspect and a curvature for all previously generated DEMs.
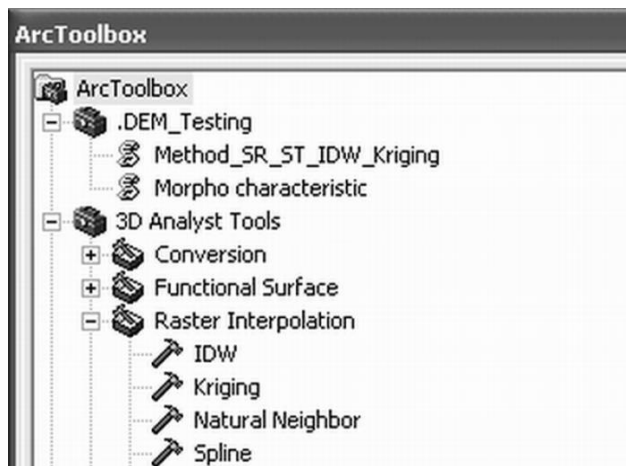

Fig.1 User toolbox "DEM_testing" in ArcCatalog

First script "Method_SR_ST_IDW_Kriging" interpolates DEM by methods: Regularized spline, Spline with tension, IDW and Kriging. Input parameters for every method are in separate text file. There are four text files. Combinations of parameters are on single lines of text file. Number of line in text files is not limited. This is an advantage of the script.

Example of text file for method Spline with tension is:

0.01,10

5,10

10,10

0.01,20

5,20

10,20

999,999

First number is the parameter for the weight, the second number is the number of points. The numbers 999, 999 are the end of file. The number of combinations of parameters can be changed for the purpose of statistical evaluation simply in the text file. New DEMs are recalculated automatically by script according new parameters in the text file after their changing.

The names of four text files for each interpolation methods are optional parameters of the script. Required parameters of the script are only the name of input point feature and the output directory (Fig. 2). If some of the text files are missing, the surface is not created for this method.

This is solved by "Try: Except:" programming construction in Python. Information messages about successfully running interpolation methods or about skipped methods were displayed to user in the result window.
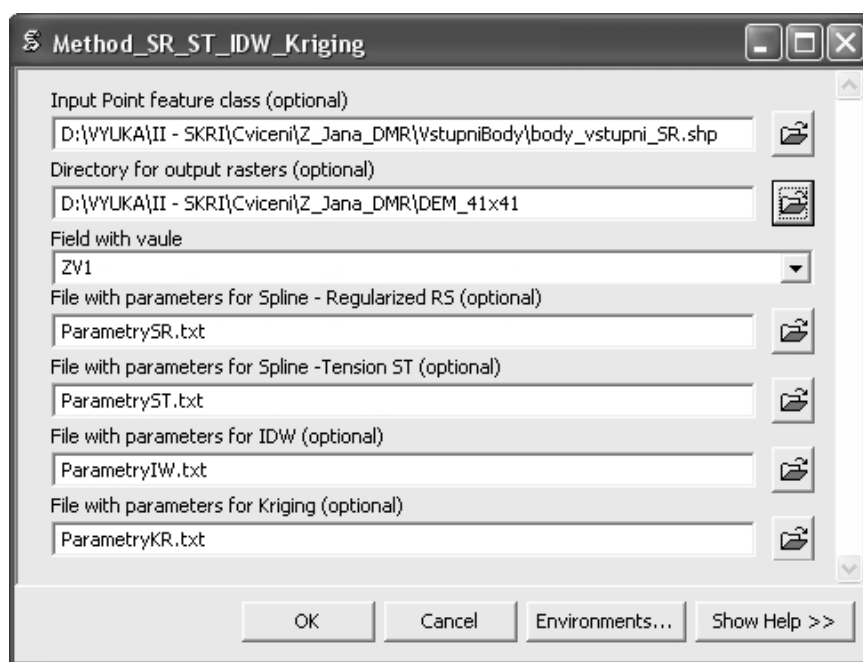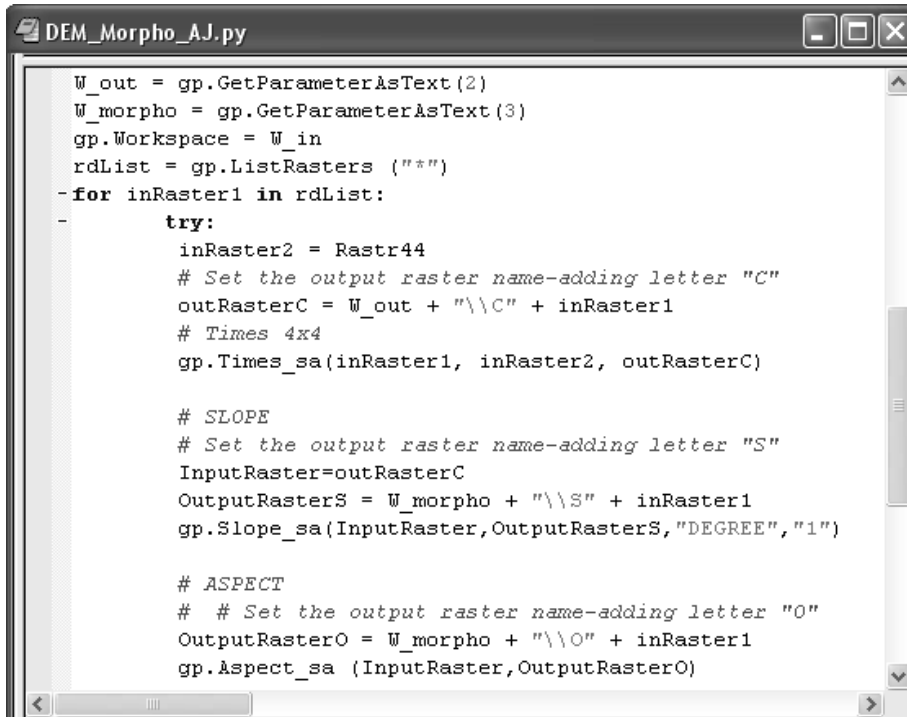

Fig.2 Interface of script for all interpolation method

It is also necessary to solve the automatic creation of file names for new DEMs in the first script. The two last letters of the point input file name is the abbreviation of the name of testing area. These two letters remain in the new name of any DEM as two last letters. The name of interpolation method is placed as two first letters of file name: SR – Regularized spline, ST – Spline with tension, IW – IDW method and KR – Kriging. The last request is to store the parameters of every interpolation method in the file name. For example, the name of surface "KR_GAU_20_SR" means: Kriging method, Gaussian semivariogram model and number of points is 20 for search radius. The name of testing area is SR - Sadska Rovina. The number of letters is limited to 12 letters in the name of DEM in ArcGIS. The creation of file name is under this limitation. The new names are very compact. It is very simple to recognize the name of the interpolation method, values of parameters and name of testing area from the file name of DEM.

The second script "Morpho characteristic" calculates morphometric characteristics. Before calculating characteristics, all surfaces are clipped exactly to 4 x 4 km by method Times. Calculated morphometric characteristics are a slope, an aspect, a curvature, a profile curvature and plan curvature. The enumeration method ListRasters is used for finding all created DEMs in program cycle (Fig. 3). The number of DEMs

can be varied. The morphometric characteristics are calculated for every founded DEM. There is also necessary to compose the name of file in the second script. Only one letter (S, O, K, R, L) according characteristic was added at the beginning of the file name. Errors are also solved by "Try: Except:" programming construction. User receives results or errors messages in the result window.

```
DEM_Morpho_AJ.py

    W_out = gp.GetParameterAsText(2)
    W_morpho = gp.GetParameterAsText(3)
    gp.Workspace = W_in
    rdList = gp.ListRasters ("*")
    for inRaster1 in rdList:
            try:
             inRaster2 = Rastr44
             # Set the output raster name-adding letter "C"
             outRasterC = W_out + "\\C" + inRaster1
             # Times 4x4
             gp.Times_sa(inRaster1, inRaster2, outRasterC)

             # SLOPE
             # Set the output raster name-adding letter "S"
             InputRaster=outRasterC
             OutputRasterS = W_morpho + "\\S" + inRaster1
             gp.Slope_sa(InputRaster,OutputRasterS,"DEGREE","1")

             # ASPECT
             #  # Set the output raster name-adding letter "O"
             OutputRasterO = W_morpho + "\\O" + inRaster1
             gp.Aspect_sa (InputRaster,OutputRasterO)
```

Fig.3 Fragment of a program code for morphometric characteristics

RESULTS OF APPLICATION

Statistical assessment of suitable interpolation method for creation digital elevation model (DEM) needs datasets for testing. An application "DEM_Testing" for automatic creation of various digital elevation models was created in Python language. The application consisted from two Python scripts.

Two scripts described in chapter "Description of the application" were used for preparing testing data. It was interpolated approximately 24 or more DEM files for one input point layer in research by the first script. More than 480 DEMs were obtained for 20 testing areas. Total number of files with morphometric characteristics was 2400. The files were divided to separate directories according testing areas. Scripts produced a huge amount of testing data.

Automatic interpolation of DEMs was quicker than manual running of every interpolation method. First script ran about 16 minutes for one testing area to obtain 24 DEMs. Calculation of morphometric characteristics (second script) ran 6 minutes for 24 DEMs. Final time was several ours for preparing all data sets. Manual creation of data maybe took several days.

The process time was depended on the type of computer. Computer technical parameters were: CPU Intel Core 2 Duo, 3.17GHz, 3GB RAM, operating system Windows XP.

Utilization of scripts has several advantages for future work. There is no problem to add new testing area. There is no problem to change combinations of parameters for interpolation method in text files.

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