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Programming Language Python for Data Processing

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***Abstract*—Geographic information systems belong the group of applications that process spatial data. Some spatial analyses are operated repetitively in the same way for different area or district. Therefore it is useful when the data processing can be run automatically by program extension designed especially for batch data processing. ArcGIS software offers a possibility to design the steps of data processing by data flow diagram in the graphic editor ModelBuilder. In some cases the data flow diagram which is designed in ModelBuilder component is not sufficient for all require tasks. In such cases, it is possible to automatically convert data flow diagram into the Python language and supplement the program code with other program constructions and commands. Some practical examples are presented in this article. All Python scripts were developed as a part of several research projects at Department of Geinformatics at Palacký University in the Czech Republic. This article is a sum of experience with scripting in Python for ArcGIS geoprocessor.**

Keywords - ArcGIS; cartography; dataflow; geoprocessor; GIS; scripting.

I. Introduction

Geographic information systems (GIS) are specific information systems that are oriented to process spatial data. Earth phenomena are represented by graphical data in a raster or vector format. Vector data are often joined with a lexical data in a relation database. The vector format uses three main forms of representation when describing reality: points, lines and polygon.

Nowadays, GIS are becoming more and more popular among municipal and territorial organizations, environmental experts for their ability to manage the spatial data [1]. Spatial decision making tasks, simulations of spatial evolution and tasks that involve comparing different data motivate growing interest in GIS. Common customers of GIS are usually familiar with interactive processing of data.

Overlay analyses are among the most often ones. These may involve clipping of a polygon or lines, creating buffers or subtraction of polygons (symmetrical difference). Operations such as "Union", "Identity" and "Identify" produce new spatial data with a combination of attribute data from source data (feature classes). GIS software are also helpful when creating cartographic output – a map. Functions for map creation are also automatically put together as sequence. These are for example operation for labeling point, line and polygon in a map and creating masking polygons for these labels. Another of the cartographic functions is a set of generalization operations. The generalization remakes the shapes of line and polygons for follow-up use in a map with smaller scale. Operation with raster data is called "map algebra". It is possible to add a raster data, reclassify a raster data etc. Raster formats are also used for representation of digital elevation model.

II. Current State of Data Flow Processing in ArcGIS

Many experienced users of GIS can construct data flow diagrams for repetitive processing of data in graphic editor. Some GIS software have a program module extension for designing the batch data processing graphically. Comparing of visual languages in GIS is further described in article "Visual programming language in geographic information systems" [2]. Software AutoCAD Map 3D by Autodesk company offers a graphic editor called the Workflow Designer. In ArcGIS, software from ESRI, the graphic editor is called ModelBuilder. Documentation explains that "Models are workflows that string together sequences of geoprocessing tools, feeding the output of one tool into another tool as input" [3]. The *"geoprocessing tools"* is a collective name for all spatial operations that can be practically used for processing spatial data. The main programming module that contains all functions is called "Geoprocessor".

The data flow model in ModelBuilder can be designed easily by "drag and dropping" any analytic spatial function and data from the interface of ArcToolBox. More than 500 tools can be utilised, depending on ArcGIS license level. Spatial functions are represented by yellow boxes while data is represented by blue or green ellipses (ovals). Ellipses represent the input and output data of spatial functions. An example of simple data flow model is on Fig. 1.

The basic function of the above mentioned example (Fig. 1) is to change the number and the shape of input polygons. Firstly, this cartographic model aggregates input polygons to one polygon. Input polygons represent the areas where infectious diseases were detected during last three years (Fig. 2.). Cartographer needs only one merged polygon for the whole period of time. Moreover, the edge of polygon for map expression must be smoother than original edges. These operations are called “generalization” in cartography. That task is realized by two polygon operation from *Cartography toolset.* Operation *Simplify* and *Smooth* were applied on one input aggregate polygon.

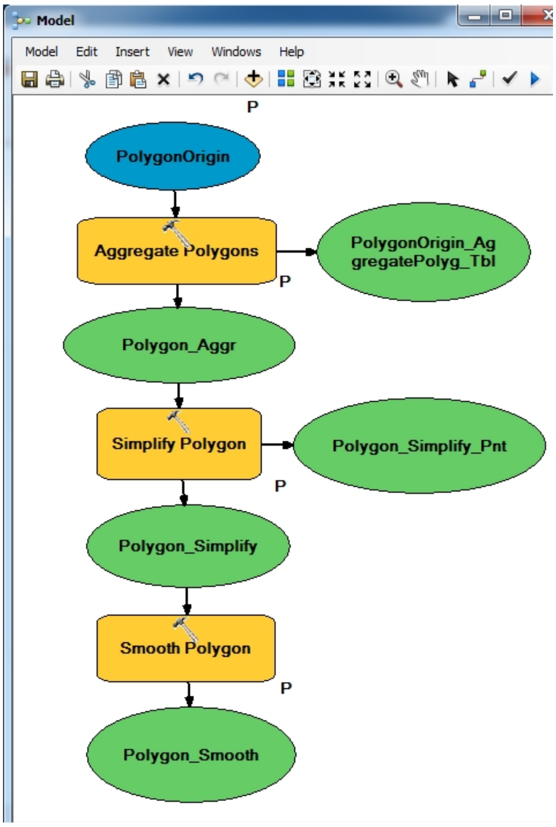


Figure 1. Example of a model in ModelBuilder.

In general, any other input data can be processed by this model. The model process input data as a batch. User receives only one final polygon that is appropriate for a map. Fig. 2 shows the change of three input polygons into a resultant smooth polygon for final map.

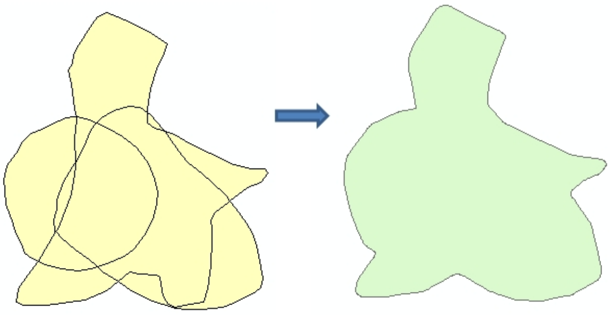


Figure 2. Input polygons (left) and output polygon (right) after cartographic processing.

III. Script in Python Language for ArcGIS

The Python scripting language is a freeware programming language. Python is an interpreted, general-purpose high-level programming language. Design philosophy emphasizes code readability [4]. As a result, Python has very clear syntax. Last version of ArcGIS 10 supports the version 2.6.5 of Python. Even though it is not the latest version of Python, it is stable for scripting in ArcGIS. All methods that can be called in a script are documented in detail in the Geoprocessor model [5] and manual [3]. All of these facts make the Python extraordinarily convenient for end users.

Scripts in Python have more advantages than models in the ModelBuilder. Basic program structures such as cycles (for, while), decision structure (if, else) can be utilized. Moreover, it is possible to avoid errors during a program run. Any unexpected error can be solved by "try: except:" programming construction in Python. In addition, notification messages can be added to *result window* for users about flow of the batch data processing. It is, in fact, recommended to output messages at the important points of the script.

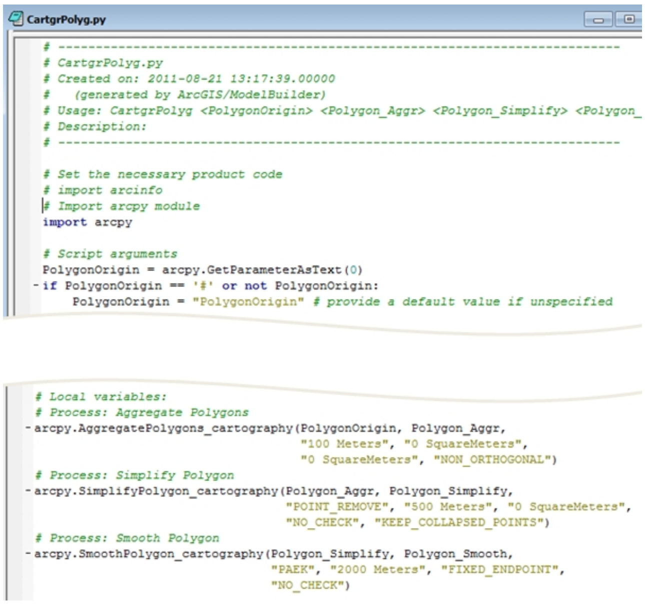
A script in Python language for ArcGIS can be created in two ways. The first way is to export existing model from ModelBuilder to the Python script. Export is supported function of the graphical editor. The second way is to directly create a script in an integrated development environment. The first way is simpler than the second especially for beginners.

A. Model Exporting

Example of exported Python script of model from Fig. 1 is on Fig.2. Automatic export creates a header with commentary lines about data, time etc. The export tool automatically imports module **arcpy** that contains library of all geoprocessing methods. Subsequently, automatic export creates commands for input parameters of scripts (name and location of input and output feature class). Finally, the geoprocessing method with parameters was added:

- arcpy.AggregatePolygons_cartography(),
- arcpy.SimplifyPolygon_cartography() and
- arcpy.SmoothPolygon_cartography().

The advantage is that the script has full functionality without any change. It can now serve as a base for other extensions in Python.



```
# ---------------------------------------------------------------------------
# CartgrPolyg.py
# Created on: 2011-08-21 13:17:39.00000
#   (generated by ArcGIS/ModelBuilder)
# Usage: CartgrPolyg <PolygonOrigin> <Polygon_Aggr> <Polygon_Simplify> <Polygon_
# Description:
# ---------------------------------------------------------------------------

# Set the necessary product code
# import arcinfo
# Import arcpy module
import arcpy

# Script arguments
PolygonOrigin = arcpy.GetParameterAsText(0)
if PolygonOrigin == '#' or not PolygonOrigin:
    PolygonOrigin = "PolygonOrigin" # provide a default value if unspecified
```

```
# Local variables:
# Process: Aggregate Polygons
arcpy.AggregatePolygons_cartography(PolygonOrigin, Polygon_Aggr,
                                    "100 Meters", "0 SquareMeters",
                                    "0 SquareMeters", "NON_ORTHOGONAL")
# Process: Simplify Polygon
arcpy.SimplifyPolygon_cartography(Polygon_Aggr, Polygon_Simplify,
                                  "POINT_REMOVE", "500 Meters", "0 SquareMeters",
                                  "NO_CHECK", "KEEP_COLLAPSED_POINTS")
# Process: Smooth Polygon
arcpy.SmoothPolygon_cartography(Polygon_Simplify, Polygon_Smooth,
                                "PAEK", "2000 Meters", "FIXED_ENDPOINT",
                                "NO_CHECK")
```

Figure 3. Python script, automatically exported from ModelBuilder.

B. *Script creation in IDLE*

IDLE Python is an integrated development environment for writing scripts. The advantages of IDLE are syntax highlighting, auto completion of commands, smart indent and integrated debugging functions (stepping, breakpoints). Partial results of scripting are displayed in Interactive window of IDLE. PythonWin is another example of IDLE for scripting. Editor window with the script is on Fig. 3.

Some methods from Geoprocessor are only accessible by scripting, e.g. enumeration methods. Enumeration methods return Python list of all file names or raster data sets in a directory on hard disk. This is one of the reasons for writing scripts directly in IDLE.

IV. IMPLEMETING PYTHON SCRIPTS

Both a model from ModelBuilder and a Python script can be loaded as a custom toolbox beside the system toolbox in ArcToolBox. Custom toolbox has a unique name. Several models or scripts can be included together in one toolbox. The final model from the ModelBuilder is stored and encapsulated in a custom toolbox in a file with file extension TBX. The Python scripts, however, are stored separately in text files with PY extension. The Toolbox only references to them via a link.

Fig. 4 depicts ArcToolBox with system toolboxes. The last toolbox on the bottom is a custom toolbox WalkAbility Index. This toolbox is used for calculating four partial and one final index that described physical motion (walking) of people in a town district. This Python script was created under the IPEN scientific project [6].

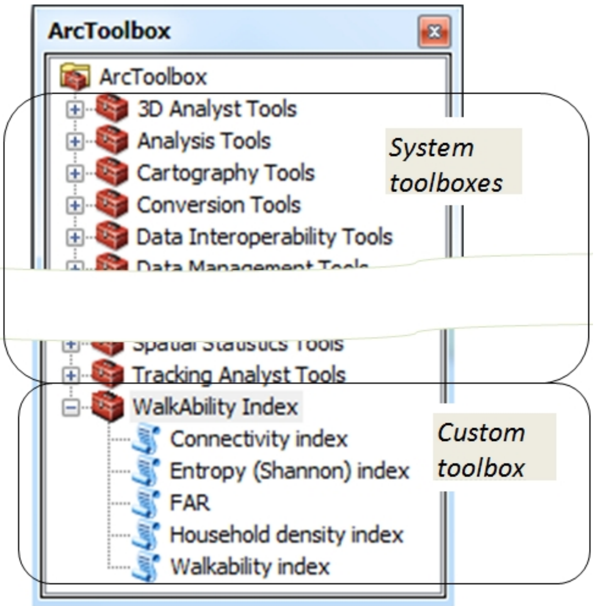
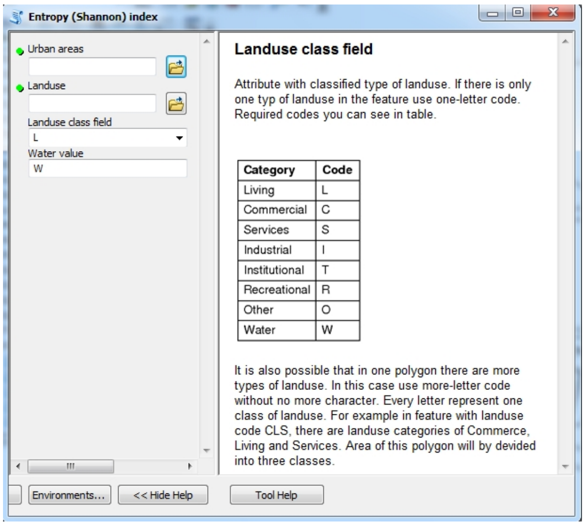


Figure 4. Custom toolboxes in ArcToolBox.

A user interface is used when setting input parameters of a script. Help notes with instruction can be joined to every parameter (Fig. 5). The instructions explain the meaning of parameters or offer suitable values.



Urban areas

Landuse

Landuse class field: L

Water value: W

Landuse class field

Attribute with classified type of landuse. If there is only one typ of landuse in the feature use one-letter code. Required codes you can see in table.

Category	Code
Living	L
Commercial	C
Services	S
Industrial	I
Institutional	T
Recreational	R
Other	O
Water	W

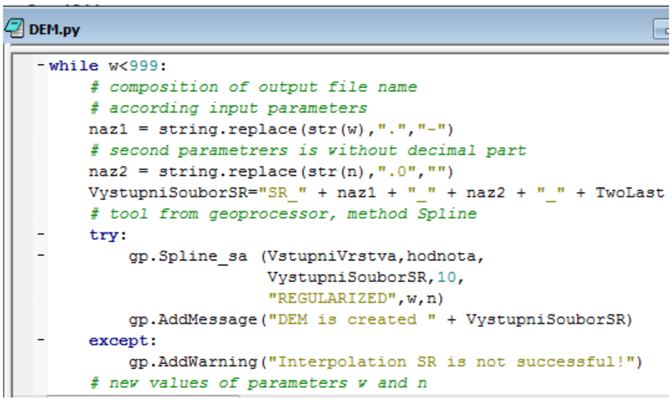
It is also possible that in one polygon there are more types of landuse. In this case use more-letter code without no more character. Every letter represent one class of landuse. For example in feature with landuse code CLS, there are landuse categories of Commerce, Living and Services. Area of this polygon will by devided into three classes.

Figure 5. User interface with help (right side) for Python script.

V. MODIFYING SCRIPTS BY PYTHON

ModelBuilder may not be sufficient in all required tasks. The program commands and function of Python can be utilized in scripts. During research about digital elevation models (DEM), over 480 testing datasets of DEMs were created automatically. It was necessary to read input parameters of various interpolation methods from text files [7]. Python has excellent basic function to open and read data from text files.

The number of letters is limited to 12 in the name of DEM in ArcGIS. Next task was to automatically create an abbreviation for the file name of DEM. String is maintained as Python list. String functions such as replace were used. The name of abbreviation was created by several program commands that put two letters together for interpolation method, four letters for numeric parameters of interpolation methods and two letters for earth area. Every two letters are separated by underscore character. The name of surface “ST_05_20_SR” means Spline with Tension method, weight 0.5 and number of points was 20 for search radius. SR is the name of explored area Sadska Rovina. Fragment of Python script is on Fig. 6.



```
while w<999:
    # composition of output file name
    # according input parameters
    naz1 = string.replace(str(w),".","-")
    # second parametrers is without decimal part
    naz2 = string.replace(str(n),".0","")
    VystupniSouborSR="SR_" + naz1 + "_" + naz2 + "_" + TwoLast
    # tool from geoprocessor, method Spline
    try:
        gp.Spline_sa (VstupniVrstva,hodnota,
                      VystupniSouborSR,10,
                      "REGULARIZED",w,n)
        gp.AddMessage("DEM is created " + VystupniSouborSR)
    except:
        gp.AddWarning("Interpolation SR is not successful!")
    # new values of parameters w and n
```

Figure 6. Python script for tnrepolation of digital elevation model.

ModelBuilder extends a base functionality of ArcGIS in batch processing. Final refining of exported model in Python can utilize a wide set of geoproccesing methods. The limitation is sometimes the time. The Python interprets every command in scripts. Therefore, the run of scripts is slower than run of complied program. The basic functionality of ArcGIS can be also extended in another way by using four application interfaces (based on ArcObjects): COM, .NET, Java, and C++. Example of practical extension based on API and ArcObject was described in article "Program Extension for Diagram Maps" [8].

VI. Conclusion

Creation of own Python script for ArcGIS is notably useful for any advanced user. Basic functions of ArcGIS program can be extended by model designed in ModelBuilder. Models are aimed mainly to batch processing of a large amount of data. Additionally, a model exported to Python language can serve as a potent starting point for final sophisticated program. Scripting in Python has some requirement on user knowledge in programming skills, understanding of individual geoprocessor methods is also necessary. On the other hand, the Python has very clear syntax and offers an integrated development environment. The three presented practical examples from the field of cartography, physical moving assessment and interpolation of digital elevation model demonstrate the usability of scripting in ArcGIS software. Scripting in Python promises to be extremely helpful for future users of ArcGIS. Furthermore, scripts reduce manual work in processing a large amount of data.

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References

[1] P. A. Longley, M. F. Goodchild, D. J. Maguire, D. W. Rhind, Geographic Information. Systems and Science, Wiley, ISBN 0471495212, 2001.

[2] Z. Dobesova, "Visual programming language in geographic information systems", NAUN/IEEE.AM International Conferences, WSEAS Press, Prague, 2011, in press.

[3] ESRI. ArcGIS Desktop Help 10, "What is ModelBuilder?" Available: <http://help.arcgis.com/en/arcgisdesktop/10.0/help/index.html#/What_is_ModelBuilder/002w00000001000000/>.

[4] What is Python? Executive Summary. Python documentation. Python Software Foundation. Retrieved 2011-08-1. . Available: <http://http://www.python.org/doc/essays/blurb/ >

[5] ESRI, Geoprocessor Programming Model ArcGIS 9.3 (http://webhelp.esri.com/arcgisdesktop/9.3/pdf/Geoprocessor_93.pdf) 2009 [accessed 19 April 2010]

[6] IPEN International Physical Activity and the Environment Network". Available: <http://www.ipenproject.org/>

[7] Z. Dobesova, “Automatic generation of digital elevation models using Python scripts”, *Conference Proceedings SGEM 2011*, 11th International Multidisciplinary Scientific GeoConference. STEF92 Technology Ltd., Sofia, Bulgaria, 2011, ISSN 1314-2704, pp. 599-604.

[8] Z. Dobesova, T. Valent, "Program Extension for Diagram Maps". Geodesy and Cartography, 37(01), Taylor & Francis, 2011, pp. 22 - 28. ISSN: 2029-7009.