

Comparison of Visual Languages in Geographic Information Systems

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Abstract—Contemporary Geographic Information Systems (GIS software) are, in some cases, extended by components for visual programming. These components are used to design a dataflow process. In this poster two examples of components are assessed. These are ModelBuilder in ArcGIS Desktop 10 and the Workflow Designer in AutoCAD Map 3D 2012. In both components for visual programming users are offered a possibility to graphically design steps for spatial data processing. The interfaces, graphic elements and a functionality scope vary greatly between these two components. An assessment is presented from both cognitive as well as usability point of view. AutoCAD Map is based on ideas of Windows Workflow Foundation. ModelBuilder is the solution by Esri Company. Moreover, an output model from ModelBuilder can be converted from graphical sketch to textual scripting language Python. The output Python script can also be used as the starting point for novice programmers.

A practical application of a model for batch processing is presented as an example that demonstrates the cartographic generalization-smoothing of vector data for the smaller map scale in ArcGIS ModelBuilder. The following example demonstrates workflow for the spatial function Create Buffer of data in AutoCAD Map Workflow Designer. The presented experiences are based on several years of lecturing at the university. Both visual components are taught within the study program “Geoinformatics” at Palacký University.

Index Terms— geoinformatics, visual programming, spatial data, cartography.

I. INTRODUCTION

Geographic Information Systems are aimed to handle advanced spatial analyses of data. Spatial analyses predict the evolution of land use, help to protect the environment, compare various situations in a city development, cartographically express spatial statistics, etc. Advanced analyses consist of various steps and combine many spatial layers in vector or raster format. The steps can be called interactively from a central software interface. Storing the order of all steps, so that the procedure can be re-used, might be beneficial for territorial organizations and other experts. The same analysis can then be repeated and applied over another area or new data from different time period.

II. BASIC CHARACTERISTICS OF MODELBUILDER

ModelBuilder creates *models*; a model represents a batch of processes for spatial analysing. Several graphic elements are used. Basic graphic elements are ovals for data. Rectangle expresses mainly functions that change data (tools). The additional hammer icon signifies a process tool. Tools are selected from the huge collection of spatial tools that are organised in ArcToolBox window (more than 500). Output data very often form an input data for the next tool (operation). An orange hexagonal symbol is an iterator. Iterators are used for repetition of operations. Arrows link elements together. It is, however, not possible to join two yellow rectangular tools without inserting an oval that expresses data. The whole procedure is designed as a chain of tools that sequentially processes data.

The orientation of a graph can be from top to bottom. The other possible orientation is from left to right (preferred in auto aligning mode). Orientation can be chosen by users. Nevertheless, the rules for graph orientation are not strictly given, which can sometimes make it confusing for another user that receives the final model for utilization. The variability in orientation results into setup which is more difficult to read in some cases. In addition, there is no explicit sign for the initial starting and end point of the whole workflow. Graphic editor has an “Auto Layout” function for automatic aligning of graphic elements. The distances between elements are automatically set to the same length, and the orientation is changed to the left – right flow.

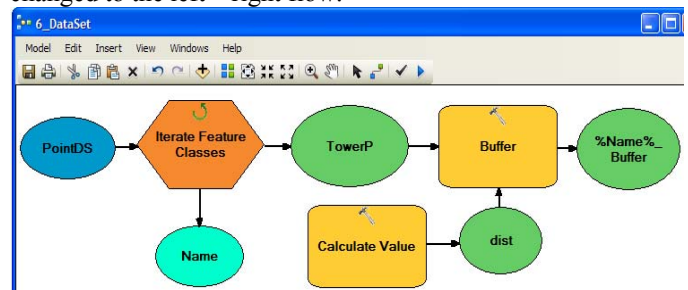


Figure 1. Interface of ModelBuilder with example model

A graphic interface of ModelBuilder also offers other helpful functions. Text labels can be put to the layout of the model. These can contain explanations, notices or titles. They have no

influence on the model function. Moreover, it is possible to zoom the model in and out, see the full extent of the model, and switch on small overview window.

III. EXAMPLE OF MODEL FOR GENERALISATION

One model can contain more lines with separate data flows. The reason for this approach is processing different data for the same purpose. Presented example is a model for cartographic generalisation. The cartographic generalization smoothes vector data for a smaller map scale. Boundary of the region is smoothed, lines of rivers are simplified, shapes of buildings are generalised. There are three separate horizontal flow lines in the model for cartographic generalisation. Each line processes different data using various tools. There is no connection between separate data flows. However, the process is not multithread.

The graphic elements for explicit expression of starting and end point of data flow are missing in basic graphic elements of ModelBuilder. The understanding of a model, reading and comprehension requires practise. Missing graphic elements for a starting point and end point is a considerable drawback.

IV. BASIC CHARACTERISTICS OF WORKFLOW DESIGNER

AutoCAD Map 3D Workflow Designer is based on Windows Workflow Foundation (WF) framework. Sequential workflow in the Designer has green indicator icon at the top of the workflow and a red icon at the bottom.

Workflow Designer uses only one graphic element – a box that represents activity. Each box has a name, an icon representing the particular function and a list of input/output data. Setting the properties of each activity is accessible using icons on the right side of its box. It is also possible to skip a box with activities by disabling it. One of limitations is in the number of activities for spatial processing. Beside the basic functions, such as data connection and selection activities, only seven overlay functions and buffer function can be added to the workflow. Nonetheless, the limitation does not arise from the interface of Designer. The number of spatial operation is lower in AutoCAD Map than in ArcGIS. Raster functions are not implemented; AutoCAD can only maintain vector data.

V. EXAMPLE OF MODEL FOR “CREATE BUFFER” OPERATION

The main process is expressed by one single rectangle. The process is a creation of buffer around line feature. Additional boxes are necessary to connect data and display the output on the map. More parameters are listed inside the box. These are distance of buffer, units, the name of the input feature class and the name of output feature class. Moreover, a small icon on upper left corner expresses the type of process.

VI. COMPARISON

The most significant difference between ModelBuilder and Workflow Designer is that, unlike ModelBuilder, the data (input and output) and variables have no graphic representation in Workflow Designer. Instead, all information about data is encapsulated in boxes - graphic elements for activities. In addition, output data from a previous activity does not necessarily have to serve as an input data for the next activity in Workflow Designer.

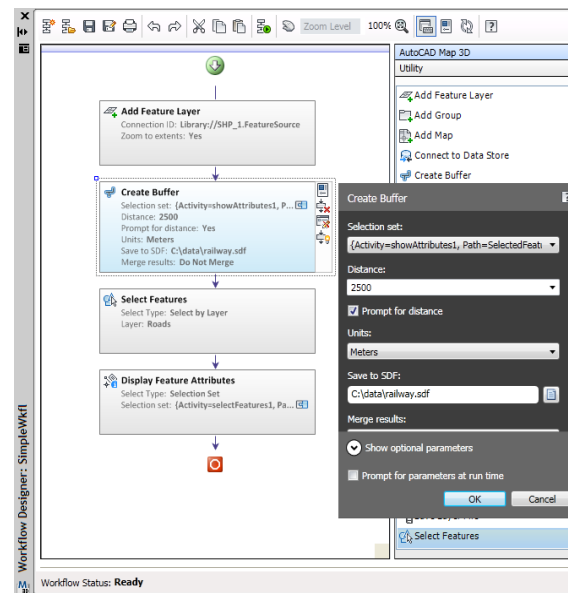


Figure 2. Workflow in AutoCAD MAP 3D 2012 for Create Buffer

Only top-down orientation of dataflow is allowed in AutoCAD Map, which results into a very clear arrangement. On the other hand, the length of dataflow can be extremely long for large workflows with separate tasks.

Basic maintenance as functions, such as “create new chart”, “save chart”, “open existing chart” and “edit chart” are present in both graphic engines. Zooming of model or data flow is also an easy task in both systems. Moreover, Workflow Designer has dynamic zooming tool. It is also possible to display whole extent of the chart. Detailed comparison table can be found in article “Visual programming language in geographic information systems” [1]. The main functional advantages of ModelBuilder are introduction of the iterators for cycling tasks, nested models, and a possibility of conversion to the Python scripting language.

Finally, we prepared a concluding discussion according to the “A Cognitive Dimensions Questionnaire” [2]. This evaluation is at its beginning. The “Section 4 - Question about main notation” contains 16 aspects in a questionnaire. Some of the aspects, questions and answers, are listed in a Table on the poster.

VII. SUMMARY

Visual programming in GIS is a very useful skill and can also help to change GIS users (geographers, environmentalists, surveyors) to novice programmers. The ModelBuilder offers more freedom in graphical design and possesses more powerful functionality compared to AutoCAD Map 3D, which is in an early stage of visual programming development. Nevertheless, the fact that Workflow Designer follows standardizations is an appreciable characteristic.

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