Spatial Tools Development at Central Washington University

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Abstract

This year's Central Washington University (CWU) GIS assistant is a programmer whose secondary duties include building ArcGIS extensions using ESRI's ArcObjects COM interfaces and Microsoft Visual C++. One extension generates erosion modeling datasets (max downhill slope angle, slope length, and RUSLE LS factor) that continues a series of AML-based programs that have been available since 1994. A second extension is a collection of utility analyses that are not available in existing ESRI software, including calculating line orientations and extracting x,y coordinates from point files. Each extension uses shapefiles or grids as inputs and will be quickly demonstrated at the conference.

Introduction

Off-the-shelf software is typically designed for the mass market, not specialized users. In particular, said software is often particularly limiting to researchers who often have niche requirements. This is the case for this project.

Like many universities, GIS has become integral to a number of programs at Central Washington University (CWU). In particular, the Department of Geography and Land Studies, the Resource Management graduate program, the Department of Anthropology, and the Department of Geosciences. As both undergraduate and graduate research are important, our students and faculty often require specialized tools. This paper describes a number of tools that have been built to fill research needs.

RUSLE Tools

The Revised Universal Soil Loss Equation (RUSLE) (Renard et al., 1997) has been around for a number of years and builds upon the original Universal Soil Loss Equation (USLE) (Wischmeier and Smith, 1978). Historically, the most difficult calculation within GIS has been the L-factor; the part of the equation that calculates the contribution of slope length to erosion. In addition, there have been problems with the GRID command FILL. Finally, when using ESRI software, slope is calculated based upon a 3x3 neighborhood, not from the center cell to the next downhill cell (which would correspond to the FLOWDIRECTION command). To rectify these issues, an AML was written (Hickey et al., 1994) to properly fill a Digital Elevation Model (DEM), calculate maximum downhill slope angle, and calculate the L-factor from a DEM for the USLE.

As time went on, the RUSLE was developed and the original AML required a facelift. Initially, the AML was revised to represent the new equation (Van Remortel et al., 2001), but later, the entire code was rewritten in C to take advantage of the very significant increase in speed possible by working from an array (Van Remortel et al., 2004). However, using this application was cumbersome, and to rectify this issue, the team at CWU converted this code into a ArcGIS extension.

The RUSLE extension was built using Microsoft Visual C++ and ESRI's ArcObjects COM interfaces. The extension was designed to be used from within the ArcMap application, using layers already loaded into a map. The L-factor calculator button on the RUSLE extension toolbar opens a dialog displaying configuration information and options the user can set to modify the procedure's parameters. A help window can be displayed in the dialog using an ActiveX Internet Explorer control window. The context sensitive help from the dialog parameter fields are linked to anchors in the HTML help file. This way the help file is stored separately and can be viewed at any time by going straight to the file system. When the user is entering data into each field, the appropriate section of the help file will be displayed in much the same way as ESRI's new toolbox dialog interfaces. Once the user makes their choice and selects 'OK', the first dialog disappears and a second dialog appears giving feedback as to the state of the analysis. Users can cancel the tool at any time via this dialog box or keep track of the progress as they continue working with ArcMap. A separate thread is started in order to perform all the time intensive work and allow the ArcMap interface to remain responsive. The thread handles exporting the DEM to a format that the C code can access and convert into an array in memory. Since you should not access the actual application object from different threads, only the source file names are passed to the thread and it loads the raster dataset directly from the file system. The thread then starts and remains in communication with a separate process via windows pipes. The process contains the C code that reads the input DEM, performs the calculations, and creates files for the output that the thread will reprocess into ESRI GRID format. The separate process was necessary to perform the calculation on large watersheds since the DEM and several intermediate calculations all have to be in memory at the same time. It was found that running a separate process greatly increased the amount of memory that could be dynamically allocated for the arrays as opposed to allocating them directly from within ArcMap. The actual maximum size of the watershed that can be processed will depend on the virtual memory capabilities of the machine. Running as a separate process also makes the code modular. The C code does not utilize ESRI formats or use any ESRI libraries. The extension bridges this code with ArcMap, and future development could be performed to convert this to a toolbox command that would not require an open ArcMap document.

A separate operation that appears as a button on the toolbar also calculates only the maximum downhill slope angle for a DEM. Since this calculation can be completed by sectioning the DEM and calculating the slope in sequential sections, no separate process is necessary and there is no maximum size to the input DEM, although as before a worker thread is used to perform the calculation while the progress dialog runs in the main ArcMap thread.

A future operation will combine all the various input layers to produce the finished RUSLE calculation.

CWU Tools

CWU Tools, at present, includes the following three applications: PointGridMaker, LineOrientation, and PolyGridStats – more will be added in the future.

PointGridMaker – This command button creates a point shapefile and fills it with a regular grid of points to the users specification. Its purpose is to create a regular grid of points that could be used as a sampling grid. The closest way to currently accomplish this would be to generate the point coordinates in an excel sheet and import them, but this may be time consuming and not straightforward depending on the extent of the grid. A raster grid may also be converted to point features to accomplish this, but it assumes the creation of an appropriate raster. This tool runs fast enough not to require a second thread or progress dialog as there is not much to go wrong with the processing. It has been suggested an option be added to generate random points with a boundary area, with the user specifying the total points to generate. This project builds off a standalone VB application available at http://www.yogibob.com/gridmaker/gridmaker.html .

LineOrientation – This tool creates displays a message box with the bearing from grid north for any line segment the user clicks near. At present, this is an interactive tool; in the future, it will add a bearing to the attribute table of each line segment in a line shapefile.

PolyGridStats – This tool gives a statistical breakdown of the number of each distinct grid cell value within each polygon in a shapefile. This is a vector/raster overlay that adds X numbers of attributes to a shapefile depending on how many distinct grid cell values are found. Currently the upper limit is set at 40 distinct values and this works only with integer raster datasets. This operation may take some time to complete depending on the inputs, so it is run in a separate thread. The input polygon features are processed sequentially with the bounding rectangle for each identified and the grid values within that rectangle queried to determine if it is inside the polygon. If so it is added to an internal array that keeps a running total until the entire bounding grid for that polygon is finished. The values are then added to the polygon object and the process is repeated.

To provide an example of how this tool could be used: Given a series of circular buffers around, say, red-tailed hawk nests, and a raster landcover grid, a question might be "what are the landcover characteristics surrounding the nests?" This tool would then add the number of pixels of each landcover type found within each buffer circle to the circle's attribute table. An analyst could then look at not only the bulk characteristics of the area around the nests, but also detailed statistics regarding the characteristics of each individual buffer zone.

Conclusions

In summary, to meet research needs, we at CWU have built a number of useful GIS applications which are not available within off-the-shelf software. As soon as they are fully tested, they will be available through the author's website: http://www.yogibob.com. With luck, these tools will continue to be upgraded, improved, and added-to.

References

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