The Raster Stamp

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Overview

The Raster Stamp tool has been developed using ESRI's front-end ArcGIS scripting library "arcpy". It enables the user to make modifications to raster datasets that follow customizable rules in relation to the geometry of input vector data. The input vector data is "stamped" onto the input raster, so that the raster cell values are modified by values calculated by a user-defined distance function. The tool combines pre-existing ESRI tools to make a flexible new tool that can be used via a graphical user interface (GUI) or imported as a python function. The tool requires an ESRI Spatial Analyst Extension License.

Steps

The process of the Raster Stamp is as follows, with a graphic representation shown in Fig. 1 using a polyline vector feature, a flat surface, a normal distance function and a subtraction operation:

1. The input vector features and input surface raster are chosen by the user.

2. The input vector features are buffered using ESRI's "Multiple Ring Buffer" tool (ESRI 2017 (1)) to create a series of buffer features representing distances from the input vector features.

3. The buffer features are assigned a z attribute value according to the user-specified distance function and staircase type.

4. The buffer features are converted to a "stamp raster" using ESRI's "Polygon to Raster" (ESRI 2017 (2)) tool. The cell size and snap raster are automatically set to those of the input surface raster.

5. A new "stamped raster" is created by applying the stamp raster to the surface raster with the user-specified operation using ESRI's "Raster Calculator" (ESRI 2017 (3)) tool.

Use

To use the script, the user must have a raster dataset to act as a surface and vector data to stamp onto it. The distance function must be specified, which takes the form of a valid python expression where the distance variable is represented as "d". This function represents the z-value with respect to distance from the input features. The user has access to the python "math" library (Python, 2016) when designing the distance function. The user also specifies a list of discrete distances at which the function will be evaluated. The distances need not be at regular intervals. The user can also specify the staircase type, which determines if the z value for each input feature should be evaluated at the buffer edges closer to the feature, the edges furthest from the feature, or the midpoint in between. The operation is also specified, indicating whether the z values should be added to, subtracted from, multiplied by or divided by the surface raster values. There are also a number of other settings that can be specified by the user to adjust the final output, which are parameters pertaining to the default ESRI tools implemented in the script.

The tool is modular and is ready for use in ESRI ArcGIS Desktop products, or can be called as a function in a larger script. To use the Raster Stamp in ArcGIS for Desktop, the user can download the script and ESRI ArcToolbox file and load the toolbox into their working document. From there, the user can run it the same as any other ESRI tool GUI. To integrate the script as a function in a larger script, the user can download the script file and place it in the same directory as their own script, and import it as a function using the command `from raster_stamp import raster_stamp`. From there, the parameters can be entered as they are described in the docstring accompanying the raster_stamp function.

The GUI for the tool also comes equipped with validation code that can quickly detect and communicate warnings and errors to the user while they are entering parameters. This helps the user to avoid common problems that can cause erroneous results and prevents time being wasted running the tool only to have it fail due to easily-preventable parameter input errors. Examples of the problems caught and communicated by the validation code can be seen in Fig. 2. The source code also comes fully documented with function docstrings and detailed comments explaining the code logic at regular intervals. These comments and docstrings are very useful to developers who wish to modify the script or implement it into their own scripts.

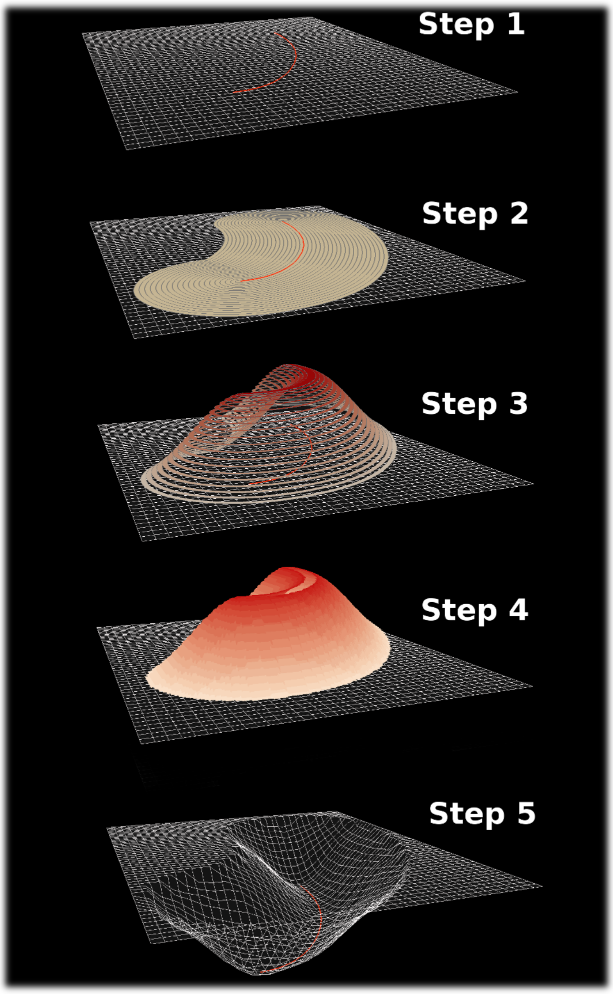

Figure 1: *Graphic representation of the process of the Raster Stamp.*

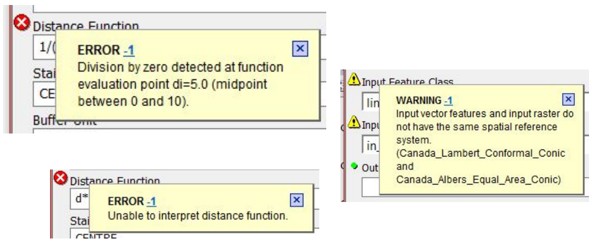

Figure 2: *Errors and warnings generated from the validation code.*

Applications

The Raster Stamp functions as an effective method of seamlessly integrating discrete vector features into continuous surface data models at any scale and resolution. It allows the user to efficiently define any mathematical relationship between vector features and their effect on their local continuously-modeled environment. The GUI allows for easy parameter adjustment when conducting exploratory research, and the modularity of the source code allows it to be used by developers as an importable function for automation of time-consuming tasks and batch data processing.

The Raster Stamp is abstract in nature and therefore lends itself directly to a great deal of potential applications. Three examples of potential applications are:

- Large-scale landscape modification such as the construction of trenches, canals, dikes, or deposit points for moved earth could be accurately modeled and simulated on an existing landscape by stamping vector features representing their general outline onto a digital surface model. Combining the original surface model and the stamped surface model would yield accurate volume calculations and estimates of required materials, time and energy. The customizable distance function would also allow the shape of the landscape modifications to be easily adjusted and optimized.

- Probabilistic modeling of phenomena that are related to distance from discrete features could be performed by designing a probability function and implementing it as the distance function. Such probabilistic surfaces could be of value when the user would like to design a field survey plan to find the most likely areas to observe a phenomenon that may be difficult to locate, such as the occurrence of an engendered species.

- Site selection for a facility that is known to degrade a local suitable habitat for a specific species, air quality and/or property values can have its effect modeled using a priori knowledge of the degree of degradation with respect to the distance from similar facilities. The ability of the user to design a custom distance function makes the tool re-usable and customizable for any new degradation model or facility type.

Further Development

Looking beyond existing applications, further development could see the Raster Stamp becoming a web geoprocessing service (WGS), which would allow users to submit their data to a web server over the internet and have the script run on a much more powerful machine elsewhere. The results could then be delivered back to the user either as a functional layer on a web map or as a raw file delivered back to the user. Such a web-based application could be implemented using ESRI ArcGIS for Server (ESRI, 2017 (4)). This kind of "software as a service" model would allow for users to run the tool very large datasets without having to purchase high-end hardware for themselves.

A potential development for more advanced use of the tool would be to allow the user to define values in the input vector feature class's attribute table to act as variables in the distance function. The variables could be accessed in the code by the field name. This would allow the function itself to be further parametrized so as to let different features modify their particular stamp shape according to their individual attributes. Such a feature would drastically increase the functionality of the tool and add another layer of customizability while not modifying its original use cases.

References

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