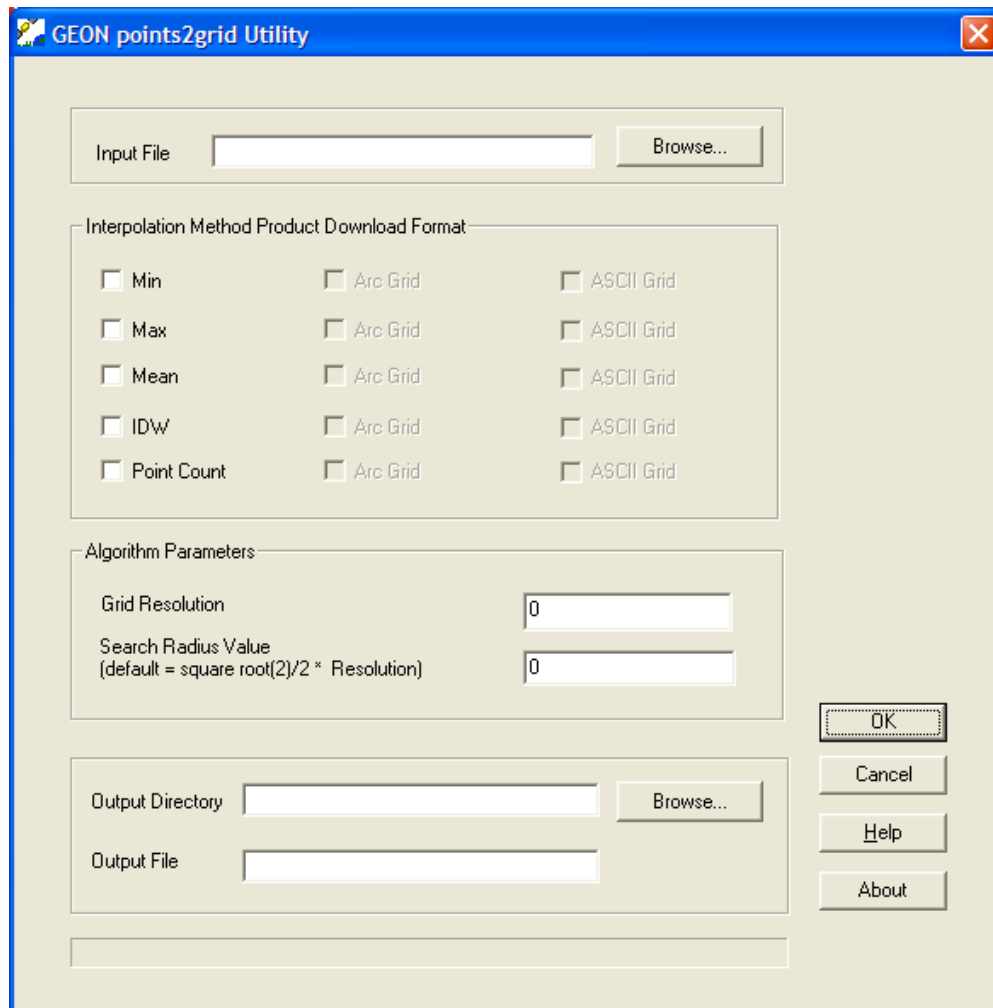GEON Points2Grid Utility Instructions
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The GEON Points2Grid Utility and associated documentation can be downloaded at:
http://lidar.asu.edu/points2grid.html

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Interface Screen Capture:

***DOCUMENTATION TOPICS*:**

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1) Introduction:

The GEON Points2Grid Utility is a lightweight tool for the generation of Digital Elevation Models (DEMs) from LiDAR point cloud data. The utility was developed by a team of geoscientist and computer scientists at Arizona State University and University of California, San Diego under National Science Foundation funding to the GEON Project (http://www.geongrid.org/). The Points2Grid Utility is now supported by the OpenTopography Facility (http://www.opentopography.org).

The Points2Grid Utility utilizes a local binning algorithm to offer rapid generation of DEMs from large volumes of LiDAR point return data. The tool offers user control over DEM resolution and the local bin (search) radius. Points2Grid operates on delimited ASCII LiDAR return data (one point per line, x,y,z + attributes) and DEMs are output from the tool in either ESRI's Arc ASCII grid or a standard ASCII grid format. Points2Grid is currently only compatible with Windows operating systems. Although originally conceived for DEM generation from LiDAR point data, Points2Grid can be used to grid any 3D point cloud data such as seismicity or gravity.

Please see the "About" dialog for copyright and authorship information. Questions, suggestions and error reports about the GEON Points2Grid Utility should be directed to: ccrosby@sdsc.edu.

2) Input File:

The GEON Points2Grid Utility reads in LiDAR point cloud data from a one-point-per-line, comma delimited ascii file where column one is x (easting), column two is y (northing) and column three is z (elevation). The presence or lack of additional attribute columns is unimportant since Points2Grid only looks at the first three columns of the file. Delimiters other than comma (or comma followed by a space) will cause Points2Grid to crash. A header on the input file is not necessary but if one is present, Points2Grid will not be affected.

Example Input files:

```
x,y,z,date,time,returnnumber,noreturns,offnidar,returnint,classification
```

```
6079558.34,2121999.58,69.06,1204,+1.39915067000000E+003,1,5,15.63,116,"G"
6079533.28,2122000.47,69.28,1204,+1.39915091000000E+003,1,5,15.18,114,"G"
6079507.99,2122001.37,69.11,1204,+1.39915115000000E+003,1,5,14.72,86,"G"
6079483.27,2122002.25,68.84,1204,+1.39915139000000E+003,1,5,14.27,84,"G"
6079555.62,2121995.47,68.74,1204,+1.39916953000000E+003,1,5,15.58,104,"G"
6079530.13,2121996.37,68.91,1204,+1.39916977000000E+003,1,5,15.12,132,"G"
6079505.12,2121997.26,68.86,1204,+1.39917001000000E+003,1,5,14.67,100,"G"
6079480.27,2121998.14,68.53,1204,+1.39917025000000E+003,1,5,14.21,77,"G"
6079455.95,2121999.00,68.28,1204,+1.39917049000000E+003,1,5,13.77,61,"G"
…


x,y,z
6211354.52,1947367.55,204.77
6211350.54,1947354.89,203.97
6211375.19,1947368.04,205.93
6211375.17,1947363.42,205.60
6211359.11,1947337.27,203.67
6211379.52,1947342.71,204.80
6211375.44,1947335.12,204.33
6211353.98,1947305.10,201.90
6211381.05,1947296.57,202.99
6211360.74,1947281.79,200.99

...
```

3) Grid Type:

The Points2Grid Utility utilizes a local binning algorithm to offer rapid generation of DEMs from large volumes of LiDAR point return data. The algorithm utilizes the elevation information from only the points inside of a circular search area of user-specified radius. For each node in a grid, five values may be computed: the minimum, maximum, mean, and inverse distance weighted mean of the local points, and the number of points in the search area. In the GEON Points2Grid Utility, the user is given the option of choosing which grids they would like to receive. For each Grid Type check box selected in the Points2Grid interface, the user will receive a DEM product – thus, if all five boxes are selected, the user will receive five grid products.

Grid Type Guidelines:

Min: The minimum surface DEM product emphasizes the lowest portions of the landscape. It assigns the minimum elevation of the points in the search radius to the grid node. In an unfiltered LiDAR point cloud, this product acts as a pseudo vegetation filter and may provide a reasonable bare earth representation. Tuning of the Search Radius parameter may be necessary to optimize vegetation removal (see *Algorithm Parameters* below for more information on search radius)

Max: The maximum surface DEM emphasizes the highest portions of the landscape. It assigns the maximum elevation of the points in the search radius to the grid node. If applied to an unfiltered LiDAR point cloud this surface represents a "full feature" or "first return" surface.

Mean: The mean surface DEM represents the average elevation of the points within the search area. It assigns the mean elevation of the points in the search radius to the grid node. For filtered (classified) point clouds, this surface is best applied to ground returns to produce a bare earth DEM.

IDW: The IDW surface DEM is similar to the mean surface product except that it uses an Inverse Distance Weighted mean to calculate the elevation at the DEM node where points closer to the DEM node are given a greater weight than those further from the node. We use a $1/r^2$ weighting in the current implementation. Like the mean surface, the IDW product is best suited to bare earth terrain model production in areas of little to no vegetation or from a filtered (classified) point cloud.

Point Count: The point count grid provides a powerful way to evaluate LiDAR point return densities and the spatial heterogeneity of your dataset. Each grid cell in this product shows the number of points found within the search radius at that node. Therefore, the point count grid can be utilized to determine what DEM resolution is supported by the dataset. In order for the local binning algorithm to produce a reasonable DEM, there must be at least a single LiDAR return in each grid cell. Multiple returns per grid cell may suggest that the dataset supports a DEM of finer resolution.

4) Product Download Format:

The GEON Points2Grid Utility generates DEMs in one of two file formats: (1) Arc ASCII Grids or (2) ASCII Grids. Both formats are very simple and were chosen because they are easily imported into many common DEM/Grid analysis software packages. The two files have fundamentally the same format but have slightly different headers as shown below.

> Arc ASCII Grid Example:
> ncols 106
> nrows 31
> xllcorner 391008.500000
> yllcorner 3826938.500000
> cellsize 6.000000
> NODATA_value -9999
>
> ASCII Grid Example:
> north: 3827123.990000
> south: 3826938.500000
> east: 391640.580000
> west: 391008.500000
> rows: 31
> cols: 106

Users must consult their analysis software documentation to determine which of these file formats can be imported.

For users of ESRI software, the Arc ASCII Grids can be imported into ArcGIS via the ArcToolBox. In ArcToolBox, select: "Conversion Tools" > "To Raster" > "ASCII to Raster". "Output data type" should be set to "float".

Arc ASCII Grid files receive an ".arc.asc" extension while the ASCII Grids get a ".asc" extension. If users select all five *Grid Types* and both *Product Download Formats* the GEON Points2Grid Utility will return 10 files.

5) *Algorithm Parameters*:
The GEON Points2Grid Utility gives users the ability to control both the resolution of the DEMs they are producing and also the search radius used in the local binning algorithm.

> **Grid Resolution**: This parameter controls the pixel resolution (or grid size) of the resulting DEM. The DEM resolution supported by a given dataset is a function of the LiDAR shot densities achieved during the data acquisition. Therefore, it is useful to know something about the dataset acquisition parameters when producing your DEMs. The Point Count *Grid Type* produced by the Points2Grid Utility can be very useful for getting a feel for shot densities in your dataset. As a general rule of thumb, most LiDAR datasets are acquired to support DEMs with resolutions of 1-3 meters.

> **Search Radius Value**: The search radius value controls the size of the bin used in the generation of the DEM. The larger the bin, the more LiDAR returns are used to perform the calculation for each DEM node. We have set a default search radius as *the (square root of 2) / 2 times the resolution* of the DEM. If a user leaves the Search Radius Value box empty in the Points2Grid interface, the default radius value is applied. Users may override the default by entering their own search radius. Larger search radii are necessary in lower shot density datasets or if the user is seeking to filter sparse vegetation in the production of a minimum surface DEM. Use to too large a search radius will result in generalization of the topography and loss of detail in topographic features.

> By default, if there are no LiDAR returns found within a given search radius the Points2Grid algorithm populates the DEM node with a NO DATA value. Thus, DEMs that are produced at resolutions higher than supported by the LiDAR dataset will contain numerous NO DATA grid cells. In this case, the user is recommended to decrease their DEM resolution or to increase their search radius.

We have a number of resources on our webpage which help users to better understand the role of search radius and LiDAR return densities in the local binning algorithm. Please see the following documents for more information:

Exploration of search radius for GEON LiDAR Workflow
(http://lidar.asu.edu/KnowledgeBase/GLW_Search_Radius)

Consideration of point count and optimal resolution and search radius for B4 ALSM data in the Carrizo Plain. (http://lidar.asu.edu/KnowledgeBase/WCptcount)

6) *Output directory*:

Use this box to define the location of where the Points2Grid products will be written.

7) *Output File*:
Use this dialog to name the output files. By default, Points2Grid will use the *Input File* name as the *Output File* and will then append descriptive extensions to differentiate the products. For example, an input file named "LiDAR_data.txt" would result in outputs titled: "LiDAR_data.txt.min.arc.asc" for a minimum surface *Grid Type* in the Arc ASCII Grid format.

FAQ:

Q: "*When the grid is computed, is the attribute of a certain pixel, relative (in the interpolation) to the coordinates of its centre (in a lattice fashion), or of one of its corner (like a pure raster)?*"

A: P2G produces a lattice grid where the attribute (i.e. elevation) is given for the center of the pixel.

Q: "*How long will P2G take to create a grid from my data?*"

A: It depends largely on the size of the output grid that is going to be generated (pixel dimensions) and very little on the size of the input file (number of points or file size on disk). Therefore, grids that cover a large spatial extent at high-resolution will take longer regardless of the number of LiDAR returns in the input file used to generate the grid.

P2G has two processing modes: In-core and out-of-core. When the size of the grid to be generated is less than the memory on the computer, P2G runs in-core (meaning it runs totally in RAM). However, when the output grid becomes larger than the RAM available, P2G runs out-of-core (meaning that it subsets the job and swaps pieces of data into RAM for processing). P2G will dynamically make the distinction between in-core and out-of-core jobs on behalf of the user.

Jobs that run exclusively in-core will typically complete in a matter of minutes. However, if the resultant grid is large enough to exceed the available memory (and thus requires the out-of-core mode), processing can take significantly longer (10s of minutes). Please be aware that while running in out-of-core mode, P2G is very resource intensive and may become unresponsive and appear to be frozen. As a result, while running in out-of-core mode performance of other applications on the computer may also be affected. When entering out-of-core mode P2G will generate a warning message with the following text:

> "Note: It can take 10s of minutes to complete processing depending on the dataset. The Points2Grid screen may become unresponsive during the process due to high CPU utilization. Do not use the Windows Task Manager to kill the process unless absolutely critical."

Q: *"I noticed is that if P2G crashes it leaves big "data_*_*" files on the "C:\Documents and Settings\username\" folder..."*

A: Should P2G crash, or you kill the process prematurely using the Windows Task Manager, the software may leave potentially large temporary files on your hard drive at C:\Documents and Settings*username*\ These temporary files are written by P2G during the course of processing and are deleted by the software at the end of a job. Should the job not make it to completion, the temporary files are not deleted automatically. We recommend that users occasionally check this location on their machine if they have been experiencing P2G crashes or are killing the software before it completes. We are currently investigating how to best automate cleanup of these files and will add this functionality in a future release.

Q: *"My input file is in the correct format but P2G crashes almost immediately when I start a job – what can I do?"*

A: P2G requires that the user have administrative rights on the machine that P2G is running. If you attempt to install and run P2G without admin rights the application will crash immediately. If you encounter this situation, confirm that your account has administrator permissions.