HTP Geoprocessor: An open-source tool for geoprocessing data from vehicle-based sensing platforms

Dr. Kelly R. Thorp
USDA-ARS, Arid Land Agricultural Research Center
kelly.thorp@ars.usda.gov
November 4, 2013

For more information, see the follow paper, currently in press:
Andrade-Sanchez, P., Gore, M. A., Heun, J. T., Thorp, K. R., Carmo-Silva, A. E., French, A. N., Salvucci, M. E., White, J. W., 2013. Development and evaluation of a field-based, high-throughput phenotyping platform. Functional Plant Biology xx (x), xx-xx. doi:10.1071/FP13126

Also, see the webinar here:
www.extension.org/pages/68270

Overview

Sensing systems on ground-based vehicles are now commonly utilized to collect data for applications in field-based high-throughput phenotyping. However, geoprocessing capability is needed to relate the sensor data to other geospatial characteristics, such as treatment plots in the field. HTP Geoprocessor is a flexible geospatial software program created for this purpose. The algorithms and user interfaces were developed as a plug-in for the open-source Quantum GIS environment (www.qgis.org). The plug-in incorporates two main tools: the Preprocessor and the Geoprocessor. The software design makes these geospatial tools readily transferable to a variety of vehicle-based sensor platforms.

Preprocessor

The main purposes of the Preprocessor are 1) to convert latitude and longitude coordinates to the Universal Transverse Mercator (UTM) coordinate system and 2) to calculate coordinate transformations from the GPS receiver to the sensor positions depending on the vehicle's direction of travel. Proper coordinate transformations are particularly important for high-throughput phenotyping, because the sensors at each position along the boom may collect data from different treatment plots. The Preprocessor tool was designed for flexibility to read sensor data in a variety of formats from comma delimited sensor data files. The user interface requires entries that provide instruction for properly reading sensor data from a file, such as the column numbers for latitude, longitude, vehicle heading, and sensor information. Offsets (m) from the GPS receiver to each sensor position are also required.

The Preprocessor expects to process sensor data from comma delimited (CSV) files only. Header information should be removed from the file. To use the Preprocessor (Fig. 1) tool, do the following:

1. Select Plugins->HTP Geoprocessor-> Preprocessor
2. Enter the total number of columns in the CSV file. The tool will not process any lines of data that do not have the specified number of columns. Blank lines will also be eliminated.
3. Enter the number of consecutive data columns to read per sensor. These are columns storing actual data from the sensor, not GPS data.
4. In the table under "Sensor Name," enter a name for each sensor included in the file. There should be entries on one line per sensor. For example, if there are four sensors, four lines of information should be completed.
5. In the table under "Latitude Column #," enter the column number containing the latitude information for each sensor (counted from left to right starting at 1).

6. In the table under "Longitude Column #," enter the column number containing the longitude information for each sensor (counted from left to right starting at 1).
7. In the table under "Heading Column #," enter the column number containing the heading information for each sensor (counted from left to right starting at 1).
8. In the table under "Sensor ID Column #," do one the following:
    a. If the data from each sensor is written on consecutive lines (Crop Circle), enter the column number containing the sensor ID for each sensor (counted from left to right starting at 1).
    b. If the data from each sensor is written on the same line (Sonar and IRT), leave blank.
9. In the table under "Sensor ID Text," do one the following:
    a. If the data from each sensor is written on consecutive lines (Crop Circle), enter the text in the sensor ID column that denotes each sensor.
    b. If the data from each sensor is written on the same line (Sonar and IRT), leave blank.
10. In the table under "First Data Column #,", enter the column number containing the first data value for each sensor. The program will consider sensor data starting here and in consecutive columns to the right, such that the total number of columns is that entered in step 2.
11. In the table under "Easting Offset (m)," enter the easting offset from the GPS receiver to each sensor. Assume the vehicle is facing north, such that west is negative and east is positive.
12. In the table under "Northing Offset (m)," enter the northing offset from the GPS receiver to each sensor. Assume the vehicle is facing north, such that north is positive and south is negative.
13. If there is any offset between the GPS system used to collect the sensor data and the GPS system used to mark the plot boundaries, enter those offsets in the boxes at the bottom left. Offsets are considered from the vehicle GPS to the field map GPS. East and north are positive. West and south are negative.
14. The "Save File" button will save this information to a file for later use.
15. The "Load File" button will load the information back into the window.
16. The "Run" button will preprocess the sensor data in a data file. When "Run" is pressed, the user is asked to select the file for processing. The Preprocessor will then process the data and save a new file with the same name, but appended with "-preprocess" between the file name and file extension. For example, "temp.csv" would become "temp-preprocess.csv". The processed file is written at the same path as the original file. If it already exists, it will be overwritten.

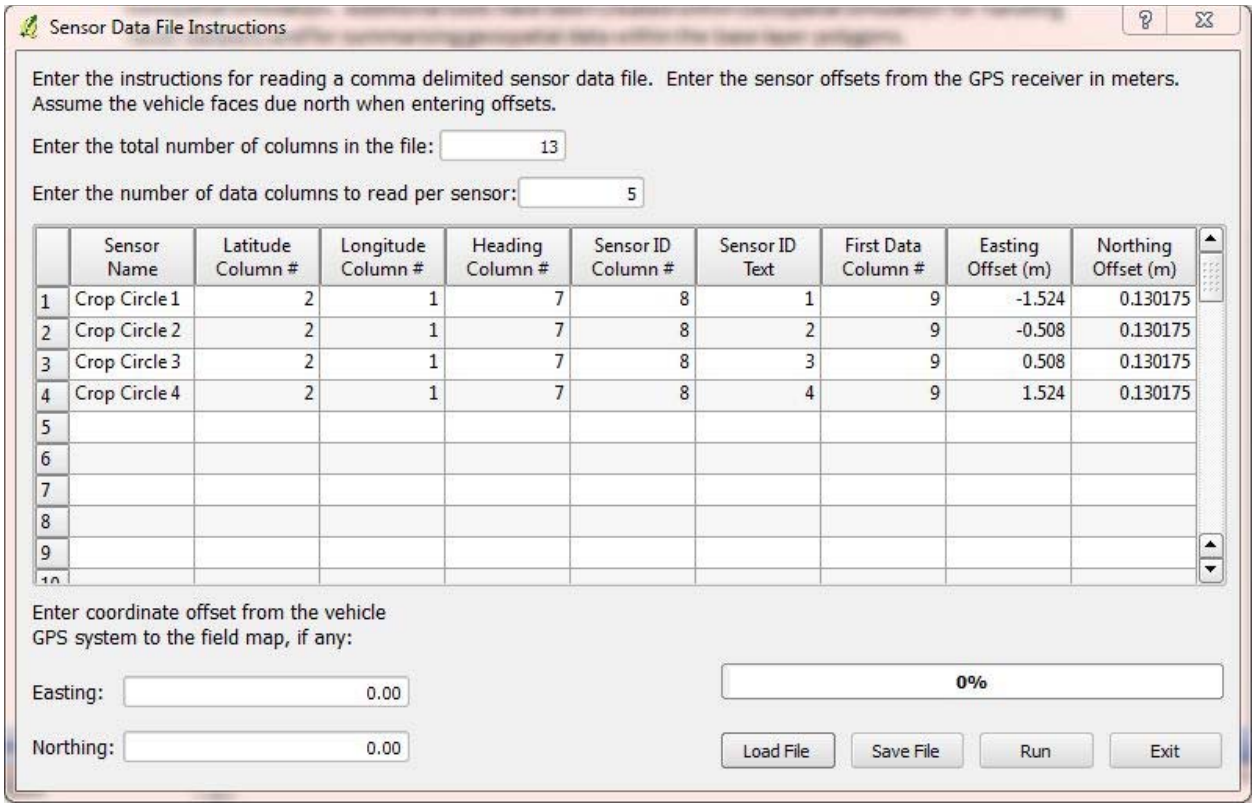

Figure 1. The graphics user interface for the Preprocessor tool.

Geoprocessor

The main purpose of the Geoprocessor is to analyze sensor data within plot boundaries, delimited by rectangular polygons. Thus, the primary requirement for the Geoprocessor is the availability of a plot boundary map, loaded as a polygon shapefile within the GIS. The Geoprocessor permits the calculation of summary statistics for sensor data collected within each plot boundary, and the statistics are appended to the plot boundary layer as attributes of individual polygons. Contrasted to the default geospatial tools commonly provided with GIS software, the Geoprocessor iteratively summarizes the sensor data independently for each feature in the plot boundary layer. The Geoprocessor also permits the assignment of a plot name to each data point, and the plot names are appended to the sensor data layer. This functionality is particularly important to prepare the data for subsequent genetic analysis.

To use the Geoprocessor tool, complete the following steps in the Quantum GIS environment.

1. Select Plugins->HTP Geoprocessor-> Geoprocessor
2. Select the processing objective from the list of available options, as follows:
    a. Find mean value of points (process layer) within polygons (base layer).
    b. Find median value of points (process layer) within polygons (base layer).
    c. Find maximum value of points (process layer) within polygons (base layer).
    d. Find minimum value of points (process layer) within polygons (base layer).
    e. Find (area-weighted) mean value of polygons (process layer) within polygons (base layer).
    f. Find maximum area polygon (process layer) within polygons (base layer). This option returns the attribute from polygon having the maximum area within the base layer

polygons. If two or more polygons have the same attribute value, their areas are summed.

g. Add attributes of polygons (process layer) to the points (base layer) falling within the polygon. Likely, this is the option needed for processing the HTP data.

3. Select the base layer polygon shapefile. For processing options 'a' through 'f' above, the combo box will be populated with all polygon shapefiles in the current workspace. For processing option 'g' above, the combo box will be populated with all point shapefiles in the current workspace.
4. Select the layer to be processed. For processing option 'a' through 'd' above, the combo box will be populated with all point shapefiles in the current workspace. For processing options 'e' through 'g' above, the combo box will be populated with all polygon shapefiles in the current workspace.
5. Select the attributes (data fields) from the process layer. For processing options 'a' through 'e' above, the list box will be populated with all numeric data fields in the process layer. For processing options 'f' and 'g' above, the list box will be populated with all text data fields in the process layer.
6. Click Run.

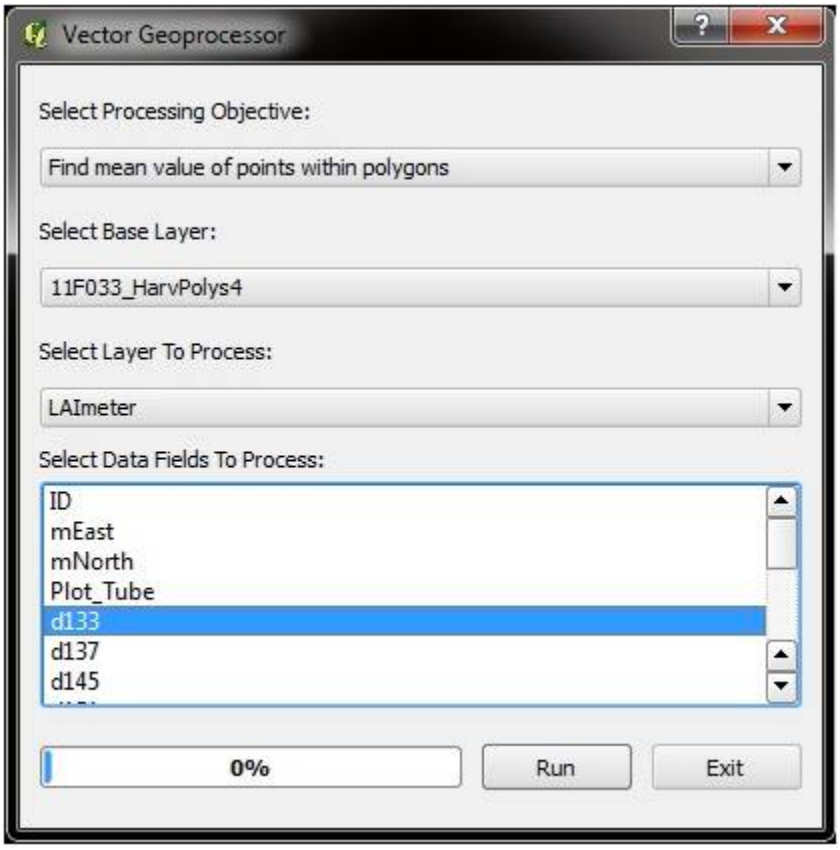

Figure 2. The graphic user interface for the Vector Geoprocessor tool.