Georeferencing by geoprocessing within a GIS

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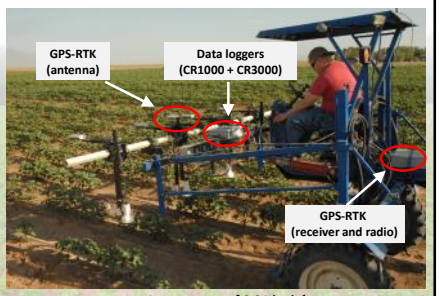
HTP: Sensors, platform, and vehicle

Infrared thermometer

Ultrasonic Transducer

Multi-spectral sensor



Average rate of 0.84 ha h^{-1}

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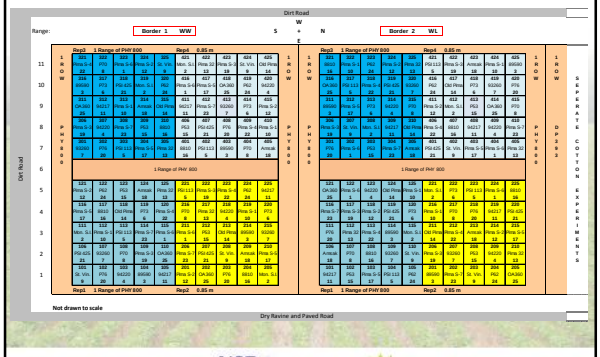
Field Map in Spreadsheet Format



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Sensor Outputs from AZ Phenotyper

- Text files: both comma and tab delimited
- Crop Circle files (comma delimited)
  - 1 of 4 sensors recorded per row
  - Use of "Sensor ID" column
  - GPS data recorded at receiver location
  - GPS data repeated for a block of 4 sensors (4 rows)
- IRT and Sonar files (tab delimited)
  - 4 (Sonar) or 8 (IRT) columns for each sensor
  - GPS data recorded at receiver location
  - One GPS record for 4 (Sonar) or 8 (IRT) sensors (1 row)
- Data formatting likely varies among and even within a particular phenotyper
- Need for standardized approaches to record and process data

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Geographic Information Systems

- Appropriately consider the geospatial nature of the data
- GRASS GIS, Quantum GIS, gvSig, ESRI ArcGIS, etc.
- Quantum GIS (QGIS; www.qgis.org)
  - Open-source, desktop GIS
  - New – Version 1.0 released in January 2009
  - Lightweight – Less RAM, hard drive, CPU requirements
  - Platform independent – Linux, Unix, Mac OS, Windows
  - Easily extendable
    - Scripts or 'plug-ins' written in C++ or Python
    - Object-oriented API for accessing QGIS functionality
    - Qt or PyQt libraries for implementing GUIs
- HTP Geoprocessor (http://plugins.qgis.org/plugins/htpgeoprocessor/)
  - Open-source Quantum GIS plug-in for processing HTP data
  - Independent of data collection in the field
  - Independent of the sensor data file structure

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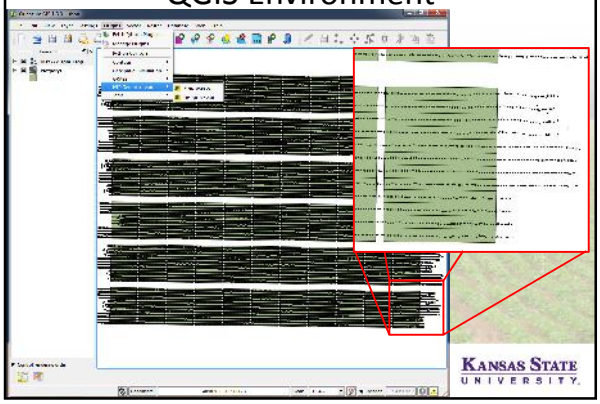
QGIS Environment



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HTP Geoprocessor Tools

- Map Creator
  - Generate a plot map from user provided coordinates
- Preprocessor
  - Read sensor data from files (independent of file structure)
  - Convert latitude/longitude to UTM coordinates
  - Calculate UTM coordinate transformations
    - From GPS receiver position to each sensor position along the boom
    - Depends on course (heading) of vehicle travel
- Geoprocessor
  - Analyze sensor data iteratively within plot boundaries
    - Calculate summary statistics for each plot
    - Assign plot ID number to each sensor data point
  - Requires plot boundary map as polygon shapefile

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Plot Map Creation Options

- Pre-plant planning
  - Draw field layout in a GIS prior to planting
  - Use auto-guided tractor to plant in predefined plots
  - Important for AZ cotton phenotyping due to drip irrigation
- Post-emergence mapping
  - Plant the field
  - Use hand-held GPS to geolocate plots after emergence
- Post-harvest data analysis
  - Conduct the experiment without mapping plot boundaries
  - Determine plot boundaries from sensor data post-processing

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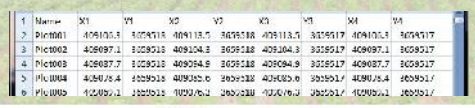
Map Creator

- Generates polygon shapefile of plot boundaries
- Comma delimited input file
  - Includes plot name information
  - Includes coordinate information
- Calculates the “convex hull” of the coordinates
  - Smallest area that contains all coordinates
- Permits different number of coordinates per plot



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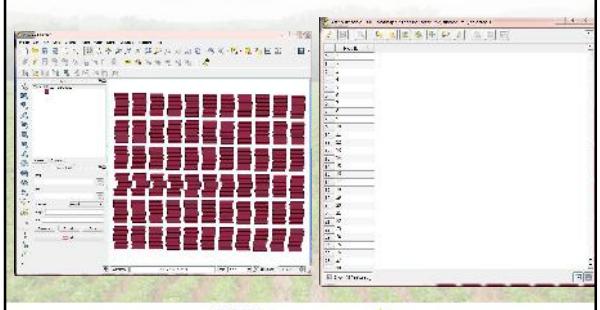
Map Creator



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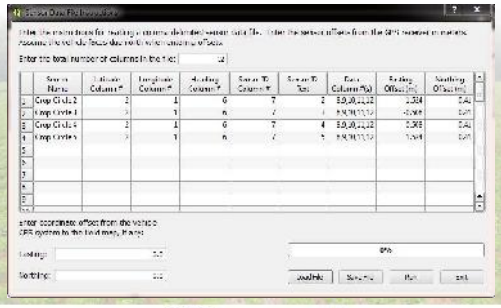
Preprocessing – Reading Data



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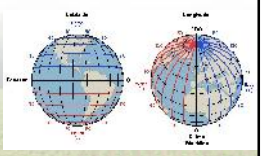
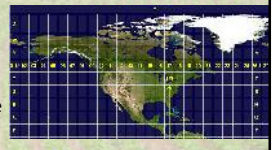
Preprocessing – LL to UTM

- GPS Receivers
  - Provide Lat/Long (degrees)
  - Provide elevation (meters)
  - Use the WGS 84 datum
    - Reference ellipsoid (shape of Earth)
    - Geoid (shape of ocean surface)
- UTM Map Projections
  - Converts Lat/Long to a Cartesian coordinate system in meters
  - Permits treatment of geospatial data by simple Euclidean distance
  - Minimal distortion at HTP scales





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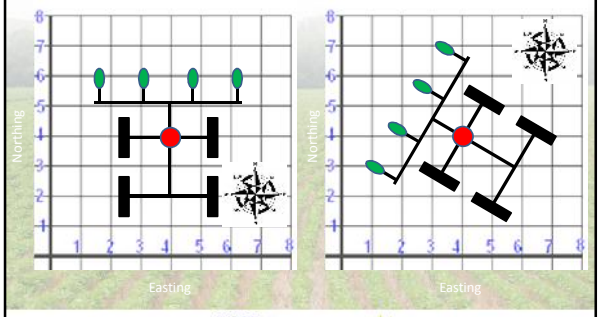
Preprocessing – Sensor Positions



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Preprocessing - Code

```
#Calculate the UTM coordinates at the GPS receiver
longitude = float(line[int(self.ui.tblInstructions.item(j,2).text())-1])
latitude = float(line[int(self.ui.tblInstructions.item(j,1).text())-1])
UTMRec = LatLongUTMConversion.LLtoUTM(23, latitude, longitude)
UTMXrec = UTMRec[0]
UTMYrec = UTMRec[1]
UTMRec = UTMRec[2]
UTMXrec= float(self.ui.txtEasting.text()) #X-offset from GPS receiver to field map, if any
UTMYrec=float(self.ui.txtNorthing.text()) #Y-offset from GPS receiver to field map, if any

#Calculate sensor coordinates based on sensor geometry and tractor heading
heading = float(line[int(self.ui.tblInstructions.item(j,3).text())-1])
headingrad = heading*math.pi/180.0
x = float(self.ui.tblInstructions.item(j,7).text())
y = float(self.ui.tblInstructions.item(j,8).text())
xp = x*math.cos( 1*headingrad) y*math.sin( 1*headingrad)
yp = x*math.sin(-1*headingrad)+y*math.cos(-1*headingrad)
UTMXsen = UTMXrec + xp
UTMYsen = UTMYrec + yp
UTMZsen = UTMZrec
```

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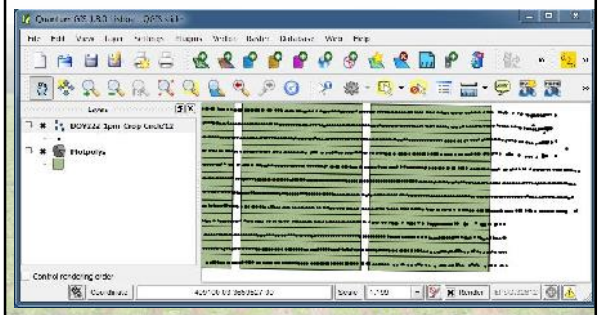
Geoprocessing – Load files into QGIS



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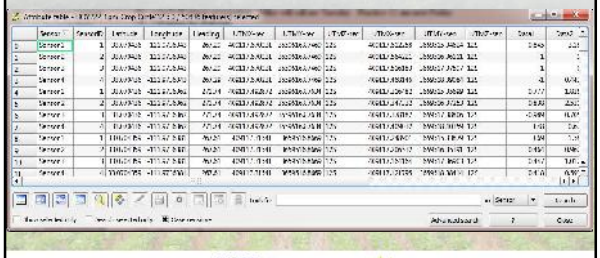
Geoprocessing – Attribute Table for Sensor Data Shapefile



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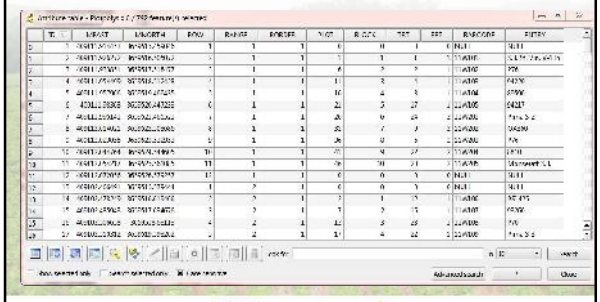
Geoprocessing – Attribute Table for Plot Boundary Shapefile



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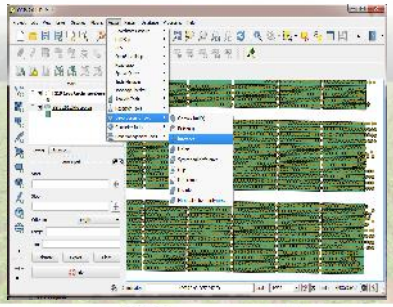
Geoprocessing – Default QGIS Tools



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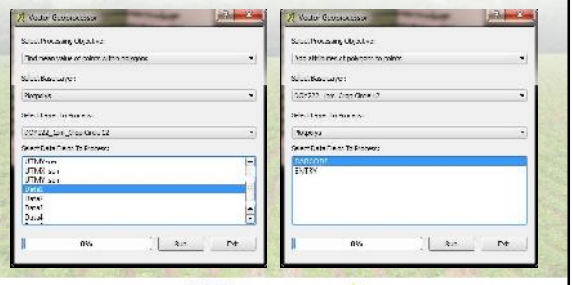
Geoprocessing – Vector Shapefile Geoprocessor



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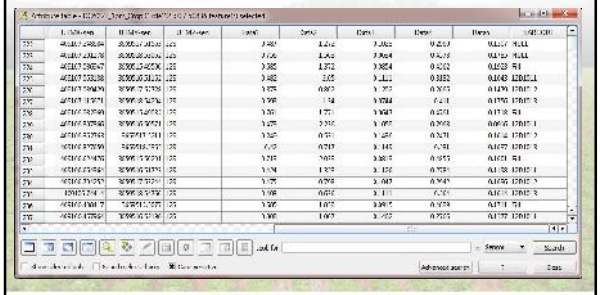
Geoprocessing – Final Attribute Table for Sensor Data Shapefile



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