



Georeferencing by geoprocessing within a GIS




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HTP: Sensors, platform, and vehicle


Infrared thermometer

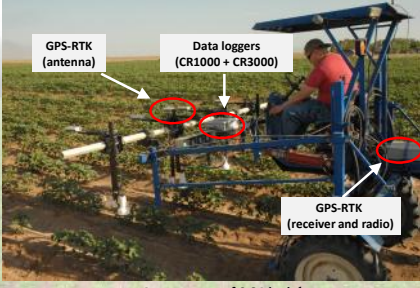



Ultrasonic Transducer



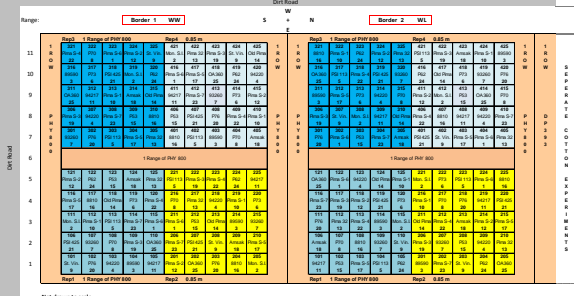
Multi-spectral sensor








Field Map in Spreadsheet Format



Not drawn to scale



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

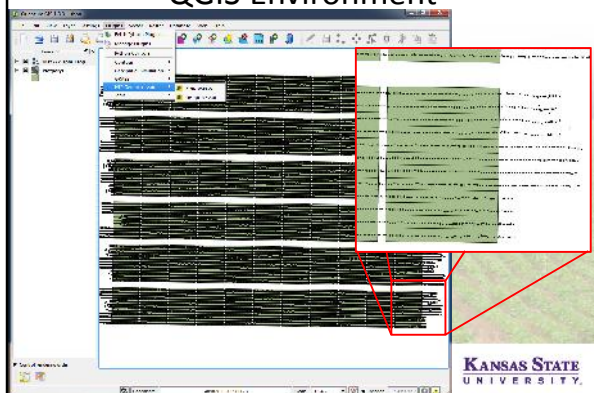


Geographic Information Systems

- 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







QGIS Environment







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

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

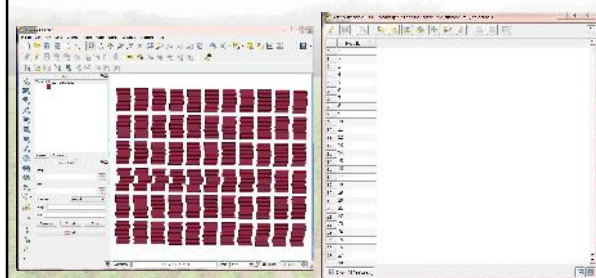
Map Creator

- 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

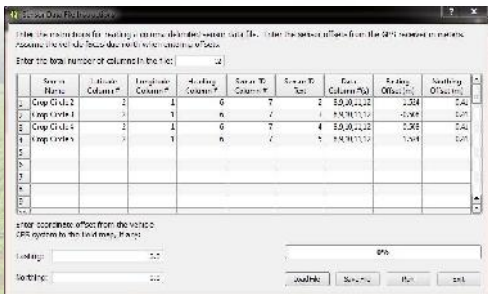
1	Name	X1	Y1	X2	Y2	X3	Y3	X4	Y4
2	Plot001	408103.8	3078718	409113.5	3078518	408113.5	3078517	409103.8	3078717
3	Plot002	408097.1	3028518	409104.8	3028218	408104.8	3028517	408097.1	3028517
4	Plot003	408087.7	3028518	409084.8	3028218	408084.8	3028517	408087.7	3028517
5	Plot004	408078.4	3028518	409080.0	3028218	408080.0	3028517	408078.4	3028517
6	Plot005	408069.1	3028518	409076.2	3028218	408076.2	3028517	408069.1	3028517

Map Creator

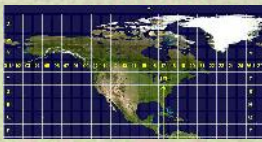
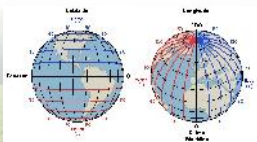


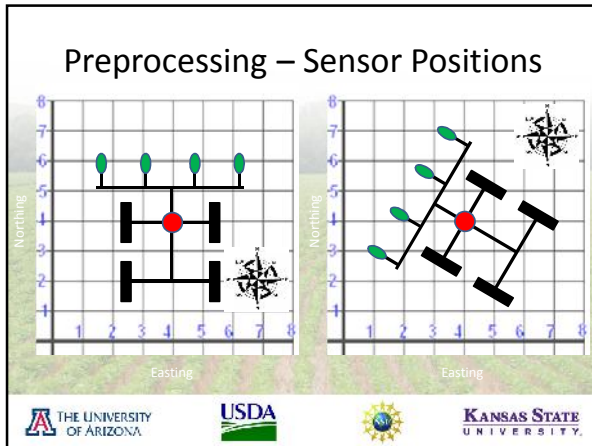
Preprocessing – Reading Data



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





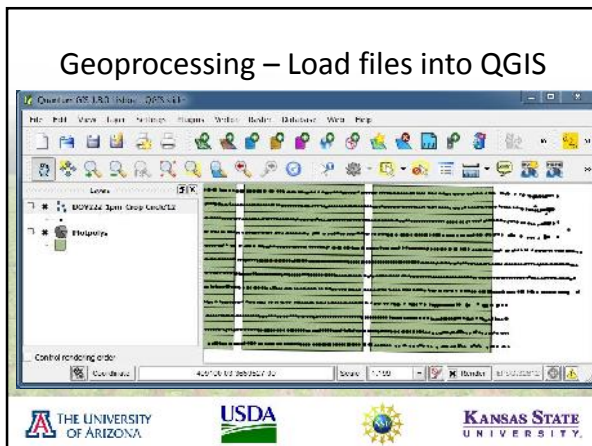
Preprocessing - Code

```

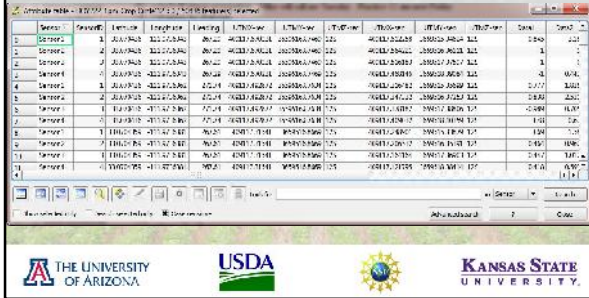
def get_gps_coordinates_of_the_gps_receiver
  longitude = float(line[int(self.ui.tblInstructions.item(5,2).text())-1])
  latitude = float(line[int(self.ui.tblInstructions.item(5,2).text())-1])
  UTMZone = LatLongUTMconversion.LLtoUTM(28, latitude, longitude)
  UTMZone = UTMZone[0]
  UTMZone = UTMZone[1]
  UTMZone = UTMZone[2]
  UTMZone = float(self.ui.txtEasting.text()) #X-offset from UTM receiver to field map, if any
  UTMZone = float(self.ui.txtNorthing.text()) #Y-offset from GPS receiver to field map, if any

def calculate_sensor_coordinates_based_on_sensor_geometry_and_heading
  heading = float(line[int(self.ui.tblInstructions.item(5,4).text())-1])
  headingrad = heading*math.pi/180.0
  x = float(self.ui.tblInstructions.item(7,7).text())
  y = float(self.ui.tblInstructions.item(7,8).text())
  xp = x+math.cos(1+headingrad)*ymath.sin(1+headingrad)
  yp = x+math.cos(-1+headingrad)*ymath.cos(1+headingrad)
  UTMZone = UTMZone + xp
  UTMZone = UTMZone + yp
  UTMZone = UTMZone
  
```

Logos: THE UNIVERSITY OF ARIZONA, USDA, KANSAS STATE UNIVERSITY.



Geoprocessing – Attribute Table for Sensor Data Shapefile

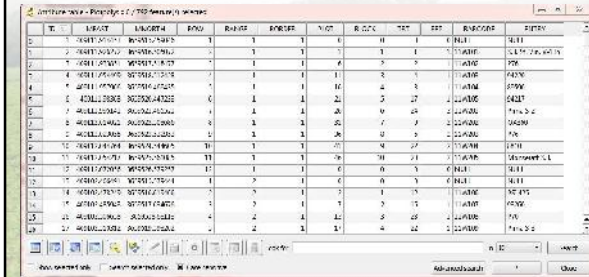


The screenshot shows the Attribute Table window in QGIS for a sensor data shapefile. The table has columns for Sensor ID, Sensor Name, Location, and various sensor readings. The data includes multiple rows for different sensors and their locations.

id	sensor	location	temp	humidity	pressure	light	gas	temp	humidity	pressure	light	gas
1	Sensor1	12345678	15.5	65	1013	100	10	15.5	65	1013	100	10
2	Sensor2	23456789	16.2	68	1012	110	20	16.2	68	1012	110	20
3	Sensor3	34567890	17.1	70	1011	120	30	17.1	70	1011	120	30
4	Sensor4	45678901	18.0	72	1010	130	40	18.0	72	1010	130	40
5	Sensor5	56789012	18.8	75	1009	140	50	18.8	75	1009	140	50
6	Sensor6	67890123	19.5	78	1008	150	60	19.5	78	1008	150	60
7	Sensor7	78901234	20.2	80	1007	160	70	20.2	80	1007	160	70
8	Sensor8	89012345	21.0	82	1006	170	80	21.0	82	1006	170	80
9	Sensor9	90123456	21.5	85	1005	180	90	21.5	85	1005	180	90
10	Sensor10	01234567	22.0	88	1004	190	100	22.0	88	1004	190	100



Geoprocessing – Attribute Table for Plot Boundary Shapefile



The screenshot shows the Attribute Table window in QGIS for a plot boundary shapefile. The table has columns for ID, X, Y, and various plot characteristics. The data includes multiple rows for different plots and their boundaries.

ID	X	Y	Area	Perim	Shape	Color	Type	Value
1	1000000	1000000	1000000	1000000	1000000	1000000	1000000	1000000
2	2000000	2000000	2000000	2000000	2000000	2000000	2000000	2000000
3	3000000	3000000	3000000	3000000	3000000	3000000	3000000	3000000
4	4000000	4000000	4000000	4000000	4000000	4000000	4000000	4000000
5	5000000	5000000	5000000	5000000	5000000	5000000	5000000	5000000
6	6000000	6000000	6000000	6000000	6000000	6000000	6000000	6000000
7	7000000	7000000	7000000	7000000	7000000	7000000	7000000	7000000
8	8000000	8000000	8000000	8000000	8000000	8000000	8000000	8000000
9	9000000	9000000	9000000	9000000	9000000	9000000	9000000	9000000
10	10000000	10000000	10000000	10000000	10000000	10000000	10000000	10000000



Geoprocessing – Default QGIS Tools

