CVEN 5391- Final project

THE EFFECT INTERPOLATION METHODS HAVE ON RESULTANT TOPOGRAPHIC SURFACES

Charles Buniger

INTRODUCTION

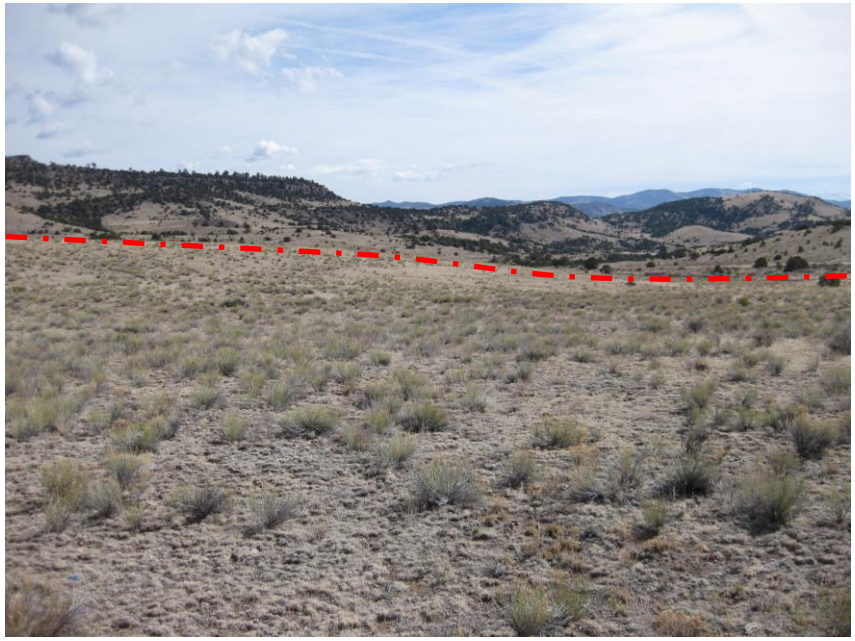
- To examine the effect interpolation methods have on the resultant surfaces
- Interpolators analyzed
  - Inverse Distance Weighted
  - Spline
  - Natural Neighbor
  - Kriging

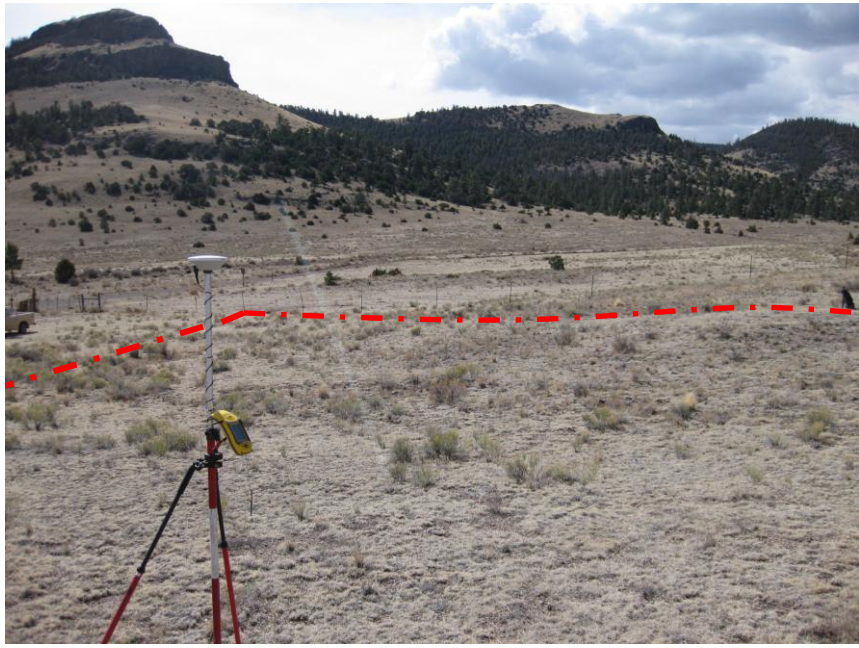
- Topographic surfaces are of great use in many industries and disciplines including civil design, land use, hydrology, geomorphology, computer science, cartography, and geomatics to name a few.

- GPS data collection: I have never collected data to create a Digital Surface Model.
  - Develop a workflow for collecting, processing, and using the data
  - Identify and solve problems that arise

DESCRIPTION OF THE AREA OF INTEREST

The Area of Interest (AOI) was located West of Saguache, CO and was chosen for its gently rolling hills, lack of obstruction on the ground, and good exposure for satellite reception. The AOI was a rectangle approximately 96m x 66m on a side and had fenceline on the South side to serve as a horizontal control.





DATA COLLECTION EQUIPMENT

- 2008 Trimble GeoXH
  - TerraSync data collection software
- Trimble Zephyr antenna

- Coordinate Reference System
  - UTM Zone 13N
  - NAD83 (2011) epoch 2010.00

- Trimble Pathfinder office software
  - Differential correction
  - Transferring files

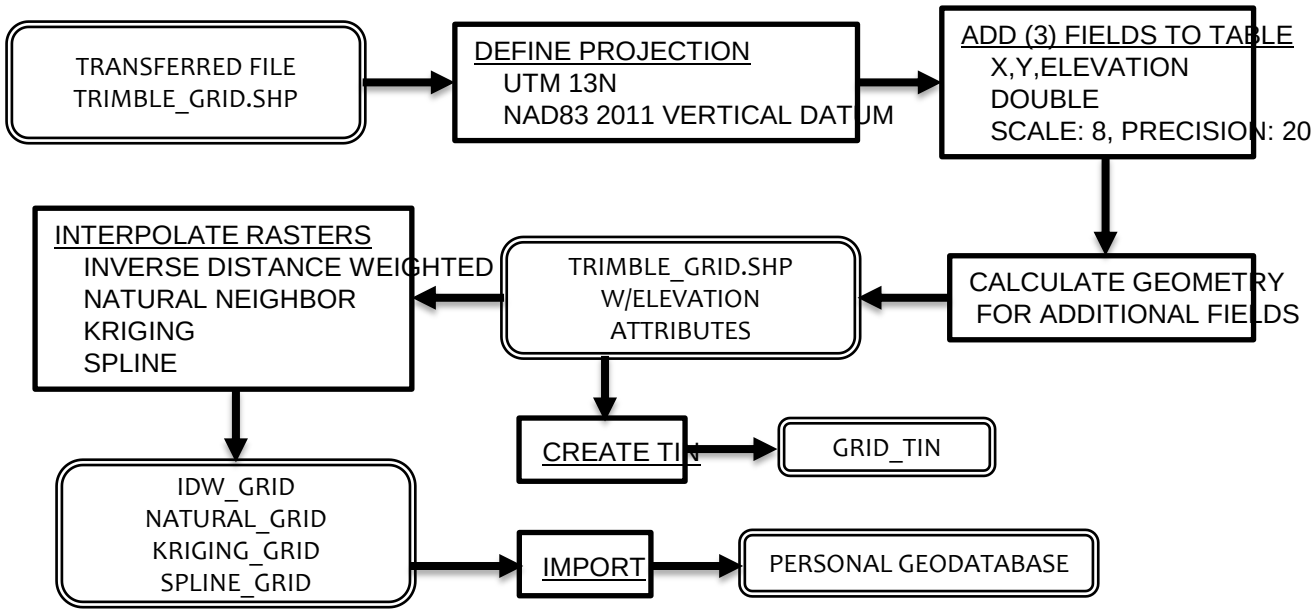
DATA COLLECTION METHODOLOGY

- Grid method utilizing a stringline perpendicular to the fenceline
  - Point taken every (10) paces, string moved over (10) paces, repeat taking points
  - Established consistent point data
  - Shortcoming: Critical features do not always occur on grid line (Ghilani 2012)

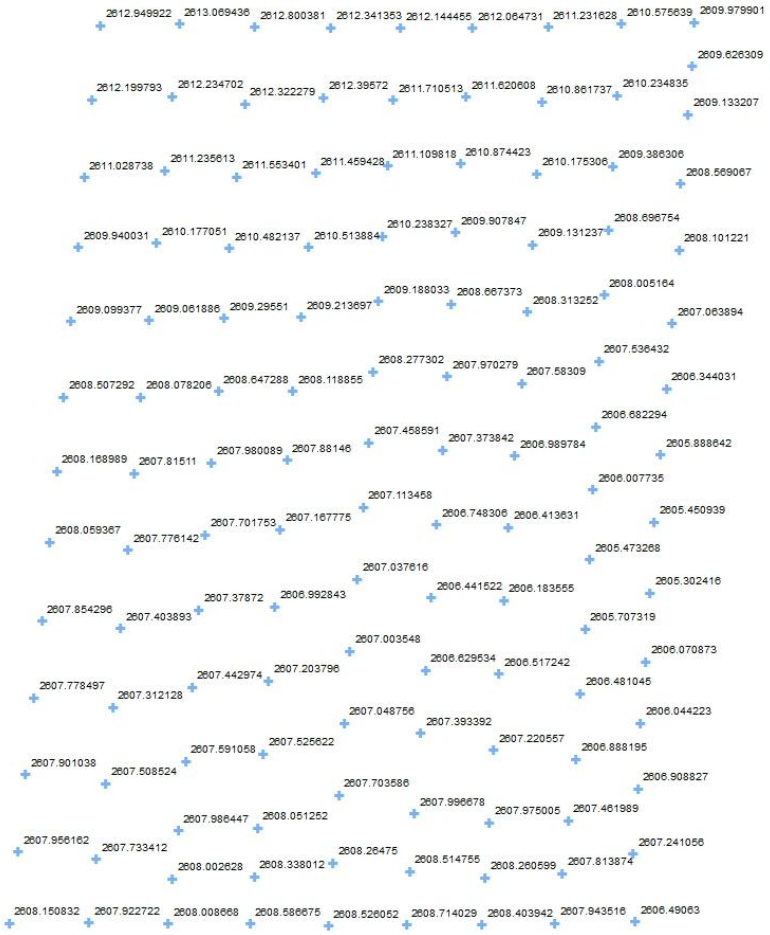
- Corners were staked out to provide control points
  - Southeast corner was designated start point so as to facilitate any data recollection if required
  - This corner also served as vertical control point

DATA PREPROCESSING

- Data transferred to personal computer and preprocessed according to the flowchart below

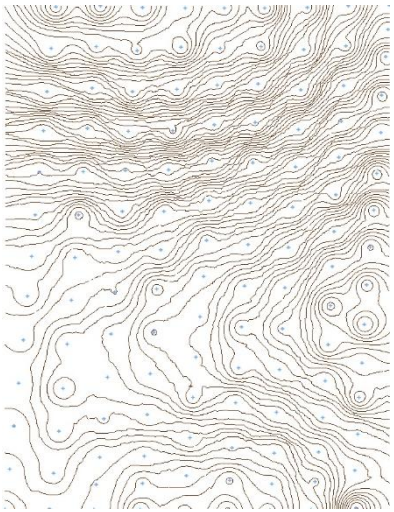


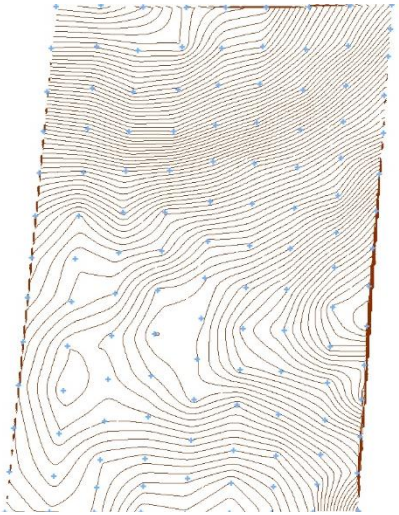
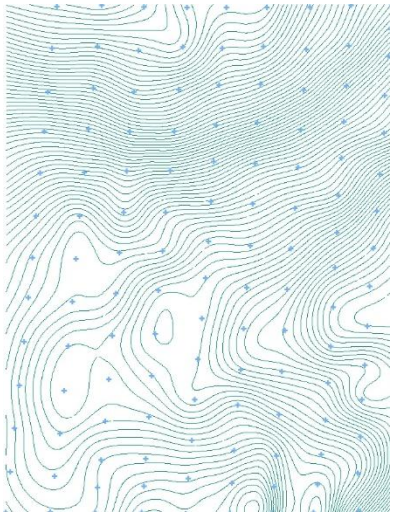
OVERVIEW OF GPS POINT DATA SHAPEFILE



DATA PROCESSING- CONTOUR LINES

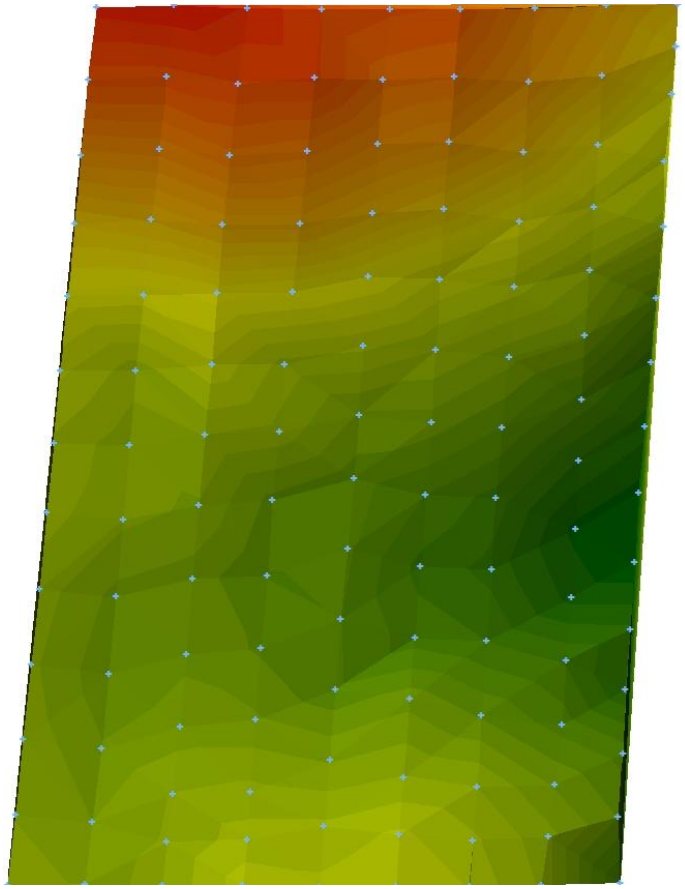
- Contour lines were generated from each of the the interpolated surfaces to provide another visual analysis tool
- The contour line creation flowchart is shown below:



DATA PROCESSING- TIN SURFACE

- A Triangulated Irregular Network (TIN) was created to aid in making the final map
- TINs are not part of the Geodatabase
- Symbology was used to create a quasi-Classification (32) classes and a color ramp applied for display
- Blue dots indicate source points



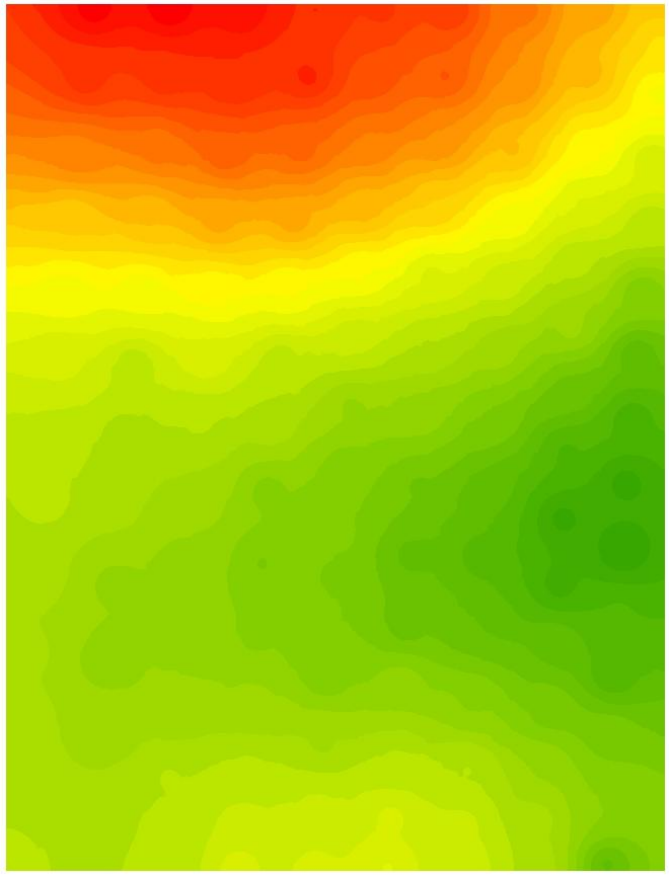
DESCRIPTION OF INTERPOLATION METHODS: Inverse Distance Weighted

- "The weight of each sample point is an inverse proportion to the distance. The farther away the point, the less weight the point has in helping define the value at an unsampled location" (Bolstad 2016)

- Local operator: only uses points in immediate, definable vicinity

- "Exact" operator: interpolated values are equal to the sampled values at each sampled point (Bolstad 2016)

RESULTS OF INTERPOLATION METHODS: Inverse Distance Weighted



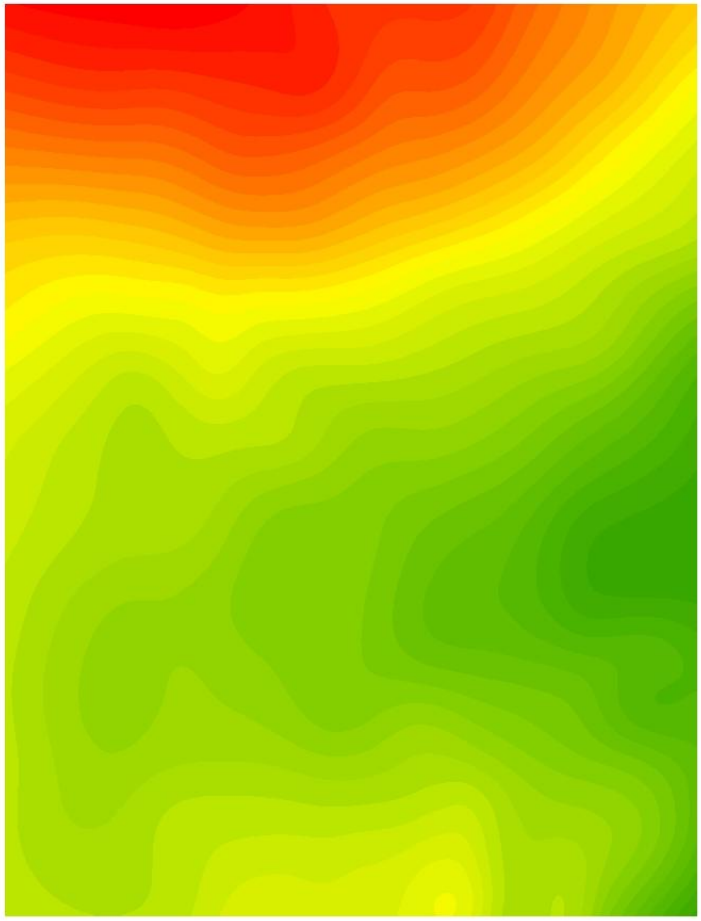
DESCRIPTION OF INTERPOLATION METHODS: Spline

- Splines are lines that are constructed from a set of joined polynomial functions. These lines pass through the sample points and seek to to minimize overall surface curvature (Bolstad 2012).

- The spline interpolator can generate results outside of the range of measured data indicating that care must be exercised during its employ and the results should be scrutinized

- Results have smooth gradually changing values

RESULT OF INTERPOLATION METHODS:
Spline



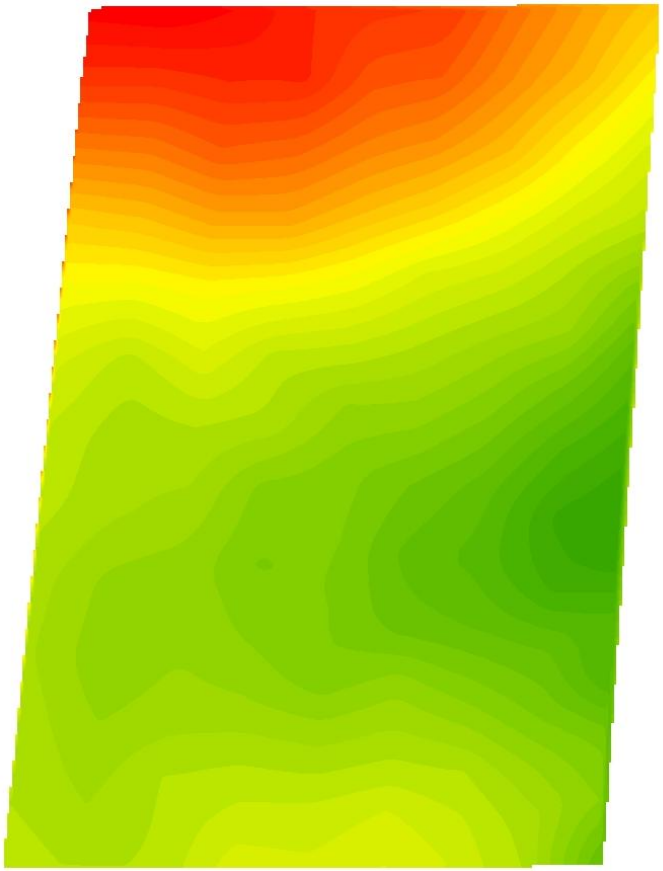
DESCRIPTION OF INTERPOLATION METHODS: Natural Neighbor

- The Natural neighbor interpolator is a local operator using only the subset of values that are closest to the queried point and applies a weight to the neighboring values proportional to their area. It then interpolates a value based on these inputs.

- The results of the Natural neighbor interpolator are guaranteed to be within the range of the input values

- This is an intuitive surface creation method and simple to employ in ArcGIS

RESULT OF INTERPOLATION METHODS:
Natural Neighbor



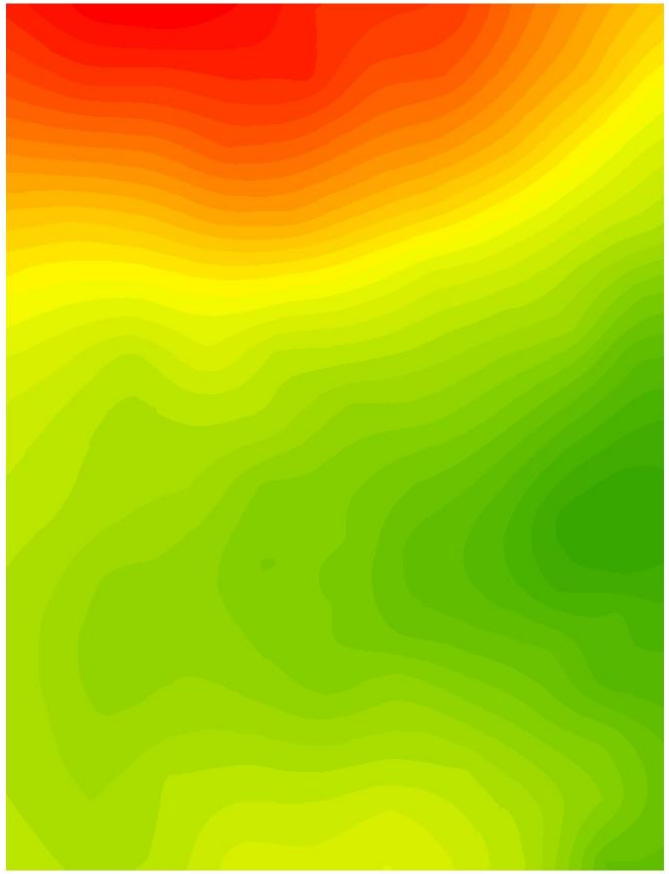
DESCRIPTION OF INTERPOLATION METHODS: Kriging

- Kriging "is a generic name for a family of least-squares linear regression algorithms that are used to estimate the value of a continuous attribute at any unsampled location" (Yeung 2007)

- "Geostatistical techniques quantify the spatial autocorrelation among measured points and account for the spatial configuration of the sample points around the prediction location" (Geostatistical analyst, n.d.).
  - This means that clumps of similar observed values have a degree of association and significance upon the resultant surface (near things are more similar than distant things).

- Many Kriging techniques and variables make very specific results possible

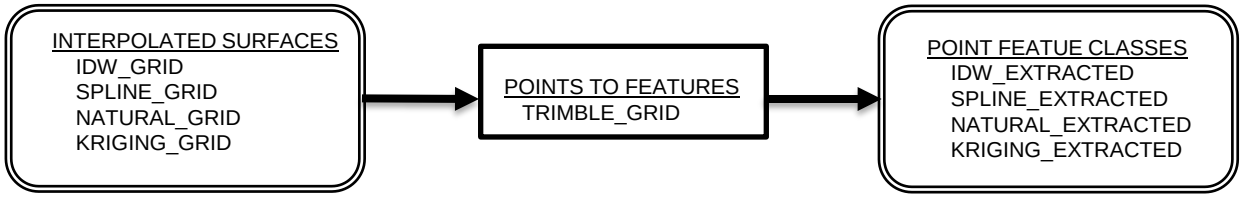
DESCRIPTION OF INTERPOLATION METHODS:
Kriging



ANALYSIS OF INTERPOLATION METHODS

- There are 126 collected GPS points that are members of the point feature class that the interpolated surfaces are derived from. The collected points have a 7.76702m range in value from a low of 2605.302416 to a high of 2613.069436

- Point feature shapefile was used as the input feature in the ArcGIS command *Points to Features* to extract the height values from the raster surfaces. (flowchart shown below) The resulting table has both the original point data with height data from the raster appended to it



ANALYSIS OF INTERPOLATION METHODS

- The resulting tables were exported in Microsoft Excel to determine which of the interpolated rasters maintain fidelity with the collected points. The calculations are shown in the table below.

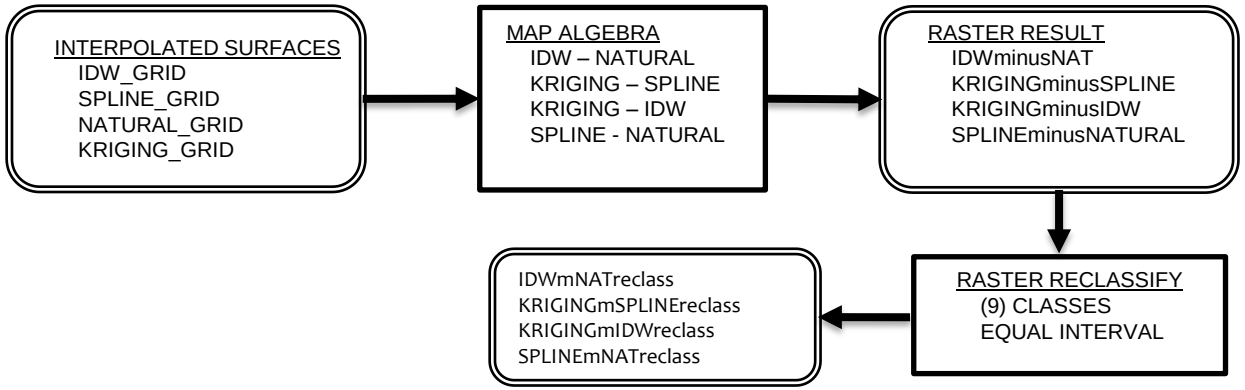
	IDW_EXTRACT	SPLINE_EXTRACT	NATURAL_EXTRACT	KRIGING_EXTRACT
∑ Points elev.	328672.019151	328672.019151	307791.196299 *	328672.019151
∑extract elev.	328672.035645	328672.155029	307792.938965 *	328672.133301
Difference	-.016494	-.135878	-1.742666	-.11415

*Natural Neighbor extracted contained (7) NULL values that were excluded from calculation.

- The Inversed Distance Weighted extracted values exhibited the least amount of change which is not surprising given that it is calculated in an *exact* manner from the collected points. All the interpolation points are very close to the sample values though.

ANALYSIS OF INTERPOLATION METHODS

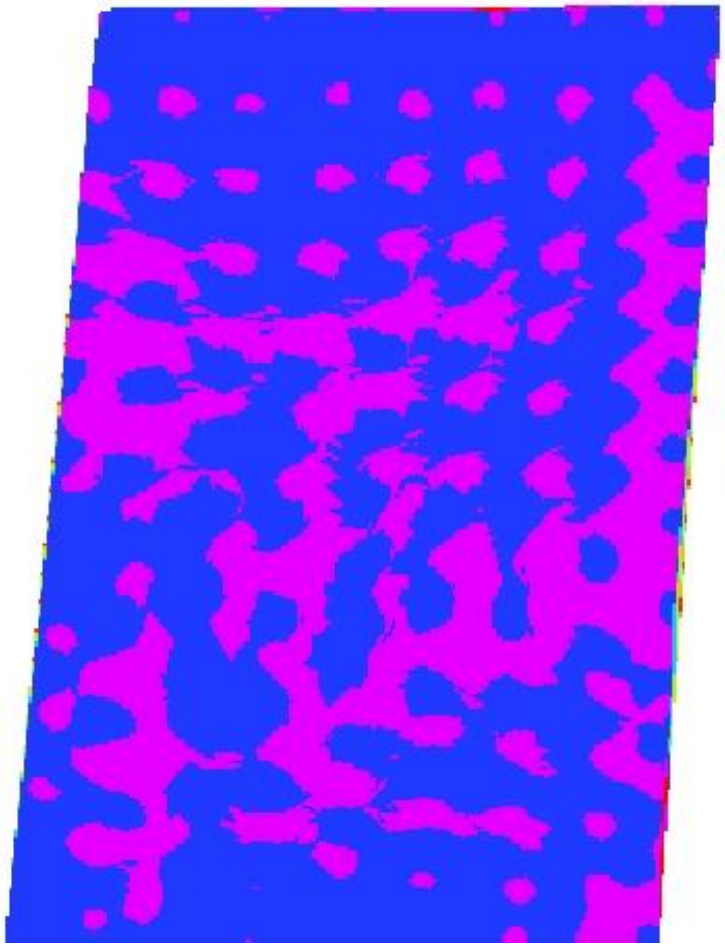
- The next analysis performed serves to compare the interpolated surfaces to each other by creating a third raster from two input rasters that illustrates the difference between them.



- The resulting third raster is then reclassified into (9) bins with equally spaced divisions across the range of difference values. This identifies areas where the interpolation methods agree and exhibit differences.

ANALYSIS OF INTERPOLATION METHODS- Result 1/4

- The Inversed Distance Weighted method Minus the Natural Neighbor method
- Blue areas indicate agreement between interpolation methods
- The methods diverge at sampled point locations

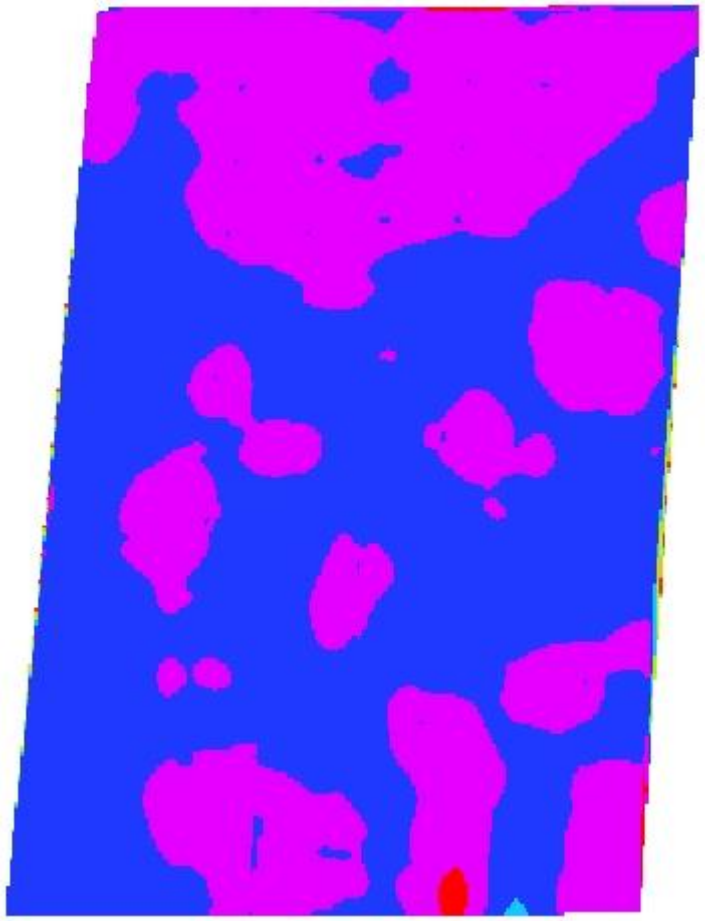


ANALYSIS OF INTERPOLATION METHODS- Result 2/4

- The Spline method minus the Natural Neighbor method

- Blue areas indicate agreement between interpolation methods

- The range of both the the blue and purple classes is 0.3125m, indicating that the interpolation methods largely agree

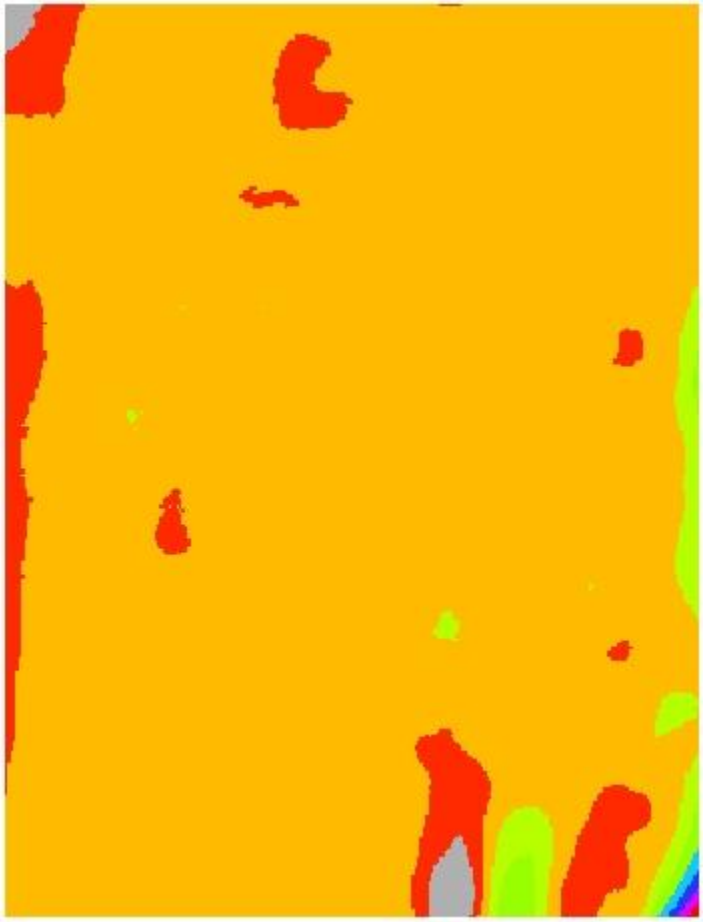


ANALYSIS OF INTERPOLATION METHODS- Result 3/4

- The Kriging method minus the Spline method

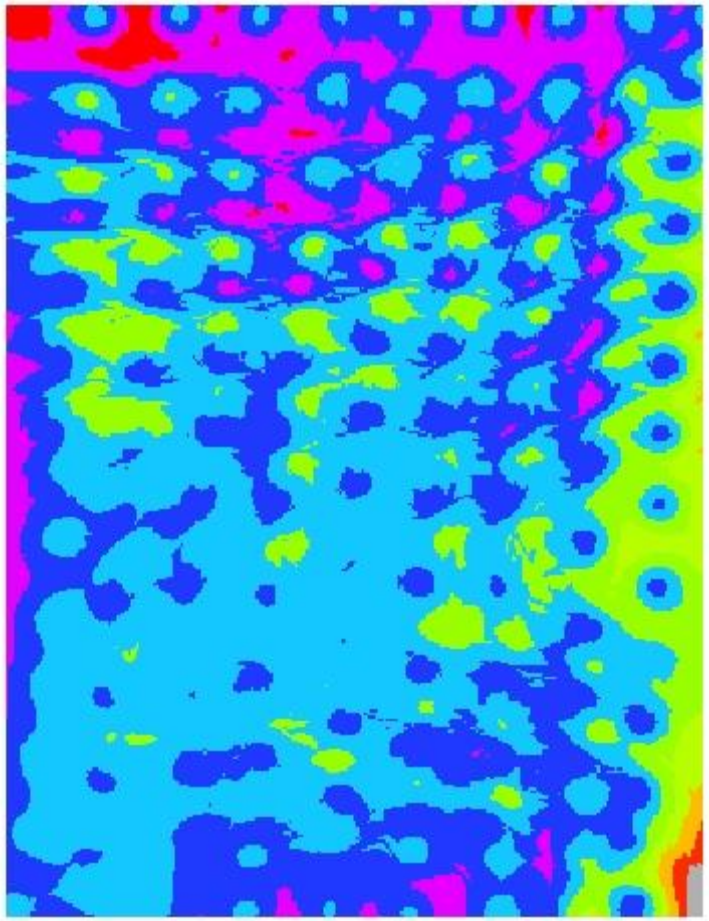
- Orange areas indicate agreement between interpolation methods

- Again, The results indicate that the interpolation methods largely agree



ANALYSIS OF INTERPOLATION METHODS- Result 4/4

- The Kriging method minus the IDW method
- TEAL areas indicate agreement between interpolation methods
- The range of values in this image is 0.934082m. This indicates that the interpolation methods yield different Results as evidenced by the green, blue, and purple areas



RESULTS AND DISCUSSION

- The different surface interpolation methods all yield usable Digital Terrain Models (DTMs)

- The Inverse Distance Weighted DTM maintains the closest values to the collected data points followed by Kriging, then Spline. Natural Neighbor had anomalous points that were removed which may have affected the final result so that interpolation method is ruled inconclusive.

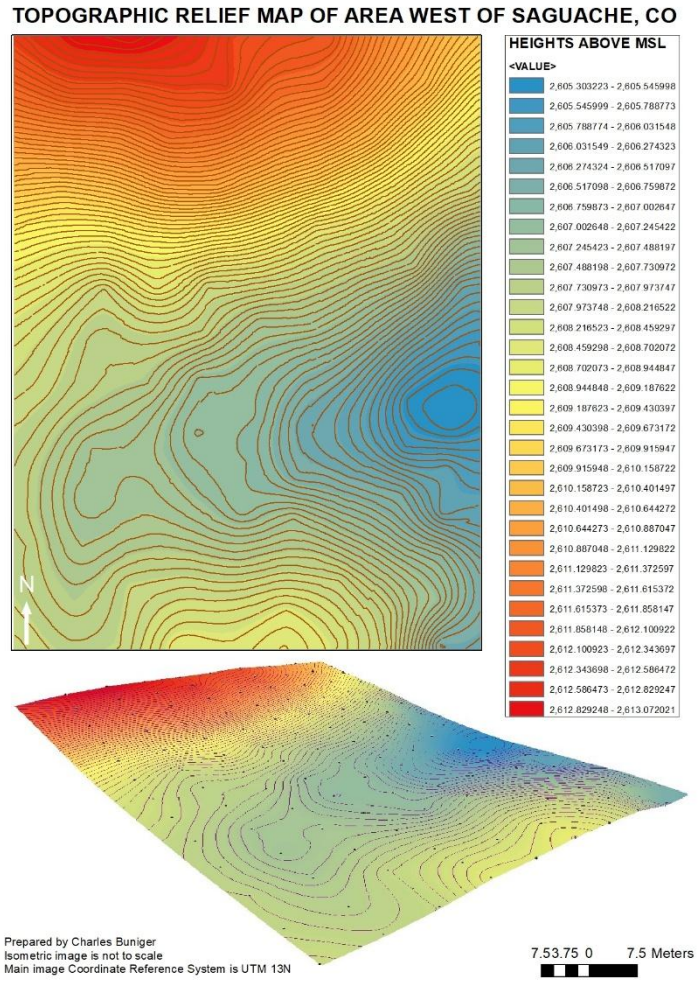
- Comparing the interpolated DTMs by creating a difference raster to highlight similarities and differences illustrated that despite being derived from the same dataset the resulting DTMs varied. The differences are significant enough that they should be taken into consideration when designing a topographic survey.

- After having objectively examined the datasets and spending time walking the Area of Interest I feel that the Kriging interpolation method offers the best balance between absolute accuracy and presentation quality.

ADDITIONAL DISCUSSION

- The importance of operation planning
  - Spend more time collecting, less time walking around
- Better best practices regarding establishment of control points and AOI layout
  - The AOI is NOT perpendicular to the fenceline
- Different collection boundaries for different data types
  - TIN had weird, jagged edges in 3d view that hindered its use for display purposes
- Different approaches and collection strategies would help create higher quality end products
  - Some localized grade changes were missed. Establishing an acceptable threshold for details would dictate any spot elevations required and decreasing the grid size in those areas would yield more accurate results.
- Overall, I'm happy with the results and had a great time!

FINISHED TOPOGRAPHIC MAP



BIBLIOGRAPHY

- Ghilani, C. D., & Wolf, P. R. (2012). *Elementary Surveying- An Introduction to Geomatics* [PDF]. Boston: Prentice Hall. pp. 470, 477
- Surface-formats. (n.d.). ArcMAP extensions. Retrieved April 26, 2018, from http://desktop.arcgis.com/en/arcmap/latest/extensions/3d-analyst/surface-formats.htm
- Geostatistical analyst. (n.d.). Arcgis tool- reference. Retrieved April 26, 2018, from http://pro.arcgis.com/en/pro-app/tool-reference/geostatistical-analyst/idw.htm
- How-natural-neighbor-works. (n.d.). Spatial analyst toolbox. Retrieved April 26, 2018, from http://desktop.arcgis.com/en/arcmap/10.3/tools/spatial-analyst-toolbox/how-natural-neighbor-works.htm
- Dent, B.D., & Torguson, J.S., & Hodler, T.W., (2009). Cartography: Thematic map design. 6th ed. Boston, MA: McGraw-Hill. pp. 166
- Bolstad, Paul. (2016). GIS Fundamentals: A First Text on Geographic Information Systems. 5th ed. Acton, MA: XanEdu. pp. 529- 532
- Yeung, A.K.W., & Lo, C.P., (2007). Concepts and Techniques of Geographic Information Systems. 2nd ed. Upper Saddle River, NJ: Pearson Prentice Hall. pp. 350-351

SOFTWARE USED AND EXTERNAL LINK

Software used

Trimble TerraSync data collection software

ArcMAP Version 10.5.1.7333

ArcScene Version 10.5.1.7333

Microsoft Excel

External link to GPS receiver specifications

http://www.gsiworks.com/GeoXH%20Handheld.pdf