Announcements

• LECTURE SCHEDULE

    Nov 30 (Wed) GPS / Spatial Analyst
    Dec 5 (Mon) 3D Analyst / GIS Competency Model
    Dec 7 (Wed) Sharing Data and Maps

• FINAL PROJECT DUE December 5 @ 1:00 PM

    TURN IN BEGINNING OF LECTURE
    Or Slide under my door before Dec 5 in Room 118 Exp. Sci. Bldg
    Or turn in to your TA before Dec 5

• FINAL EXAM – Strongly recommend begin studying now
    Dec 13th Final Exam 1:30 pm

• SPRING 2017
    - GIST 4304 (Full) / GIST 5304 Advanced GIS

• FALL 2017 ?

GIST 3300 / 5300
Geographic Information Systems

Class Lecture Evaluations
& for Monday Lab @ 2 pm

Field Mapping with GPS (cont.)

Spatial Analyst
GIST 3300 / 5300
Geographic Information Systems

Field Mapping with GPS

Planning

Data Collection

Post Processing
Pathfinder Office (post-processing)

Field Mapping with GPS

Planning

Data Collection

1) GPS Toolbar in ArcMap
2) Trimble TerraSync (data collection)
3) Esri ArcPad (data collection)
   GPS Correct Extension for ArcPad
4) Esri Collector

Post Processing
Pathfinder Office (post-processing)
Regional Navigation Satellite Systems

1) US – WAAS – Wide Area Augmentation System
2) China – BeiDou Navigation Satellite System
3) EU - Galileo
   - China & EU both planning to be global by 2020

4a) India – IRNSS – Constellation of satellites for navigation around the Indian Subcontinent
4b) India – GAGAN (GPS-Aided Augmentation Navigation) satellite-based augmentation system – enhances accuracy of NAVSTAR GPS and GLONASS positions

5) Japan – QZSS – Quasi-Zenith Satellite System
6) France – DORIS - Doppler Orbitography and Radio-positioning Integrated by Satellite (cm precision)

GNSS Online Planning Tools
After your planning, you have a choice of how you want to collect your GPS data.

1) GPS Toolbar in ArcMap
   - Can use the GPS toolbar in ArcMap
   - Connect to your GPS unit and collect data in the field
   - Need ArcMap and a laptop
   - Sometimes difficult to work with a laptop in the field without a vehicle

2) Field Mapping with TerraSync (Trimble) on a GPS unit

   TerraSync software
   - Trimble’s version of mobile field mapping and data collection software
   - Designed to run on Windows Mobile and Tablet devices
   - Allows the users to capture and edit GIS data in the field
   - Provides excellent control over your GPS receiver
3a) Field Mapping with ArcPad (Esri)

ArcPad
- mobile field mapping and data collection software
- designed to run on Windows Mobile and Tablet devices
- allows the users to create, edit and analyze GIS data in the field
- can be used as a stand-alone system for data collection or as part of a multi-user enterprise system (with ArcSDE)
- allows field crews to check out data, edit the data in the field, and check it back in

ArcPad interface works in a manner that is similar to ArcMap
- can add:
  - shapefiles
  - feature classes
  - raster layers
  - and imagery
- many standard tools:
  - navigate to features
  - capture GPS coordinates
  - add attributes
  - edit features
  - identify, select, query
  - symbolize
  - and display
3b) GPS Correct (Trimble) for ArcPad

GPS Correct Extension for ArcPad
- a Trimble product designed to add more control over your GPS receiver within ArcPad
- many of the same functions we find in TerraSync

- Satellite Status
- Set-up
  - GPS (PDOP)
  - Real Time
  - Coordinate System
  - Units
  - External Sensors

4) Esri Collector for ArcGIS – works on Cell phones
- not a professional grade GPS data collection system – but a very useful app
- allows the user to collect field data on a smartphone (iOS or Android)
  - download the application from Apple App Store or Google Play
- must have a subscription to ArcGIS Online (maps stored in the cloud)
  - download maps to your device and work offline
  - use GPS to create and update map data
  - collect points, lines, and area features
  - fill out map-driven forms.
Differential Correction – Post Processing software
Trimble GPS Pathfinder Office

- differential corrections to improve the quality of GNSS data collected in the field

- GPS data collected by the rover (rover files) are corrected using GPS data collected at a selected base station

- these base station files can be downloaded from Coast Guard or TxDOT

- support for both GPS and GLONASS post-processing

- provides a measure of quality control of GNSS data before exporting to GIS

Summary of Field Mapping Software

- GNSS Planning Online: before collecting data

- Field Mapping Software: collect data in the field with a GPS unit
  1) GPS toolbar in ArcMap
  2) Trimble – TerraSync
  3a) Esri – ArcPad
  3b) with optional GPS Correct (Trimble TerraSync capability)

- Field Mapping with cell phones
  4) Esri Collector for ArcGIS

- Differential Correction Post Processing software
  Trimble Pathfinder Office
Spatial Analyst

ArcGIS Extensions

Spatial Analyst Extension
- adding the extension
- loading the toolbar
- major functions
  - distance
  - density
  - interpolation
  - map algebra
  - surface analysis

Extensions Add More Functionality to ArcGIS
- there are dozens of extensions for ArcGIS
- designed to add more functionality (tools) to the core software
- most of these extensions add a toolbar to the ArcMap interface and unlock additional tools in ArcToolbox
- some of the extensions are developed by Esri
- some have been created by other software developers
- some extensions are available as a free download
- some extensions require a software license $$$
ArcGIS Extensions

- Spatial Analyst – used mainly to analyze raster data
- 3D Analyst – view and analyze data in 3D
- Geostatistical Analyst – visualize, analyze & understand spatial phenomena
- Network Analyst – works on linear data ex. road networks
- Tracking Analyst – real time GPS tracking of features
- Survey Analyst – for detailed survey data
- Business Analyst – specialty marketing and competition analysis
- Military Analyst – terrain analysis and planning

Two steps to work with an extension

1) Activate extension (check box for desired extension)
Two steps to work with an extension

2) Add the toolbar (won’t work without first activating extension)

- Opens Spatial Analyst toolbar with activated tools

Spatial Analyst

Surface Analysis tools
- Aspect
- Contour
- Hillshade
- Slope
- Viewshed
Spatial Analyst

Interpolation tools
- IDW
- Kriging
- Spline
- Topo to Raster

- used to interpolate a surface from sample points or contour lines

Spatial Analyst

Distance tools

Euclidian tools:
- used to create a continuous raster distance, direction and allocation surface from either point, line or polygon features
You have been hired by a large city as their new GIS project manager. The voters of the city have recently passed a bond issue that will provide sufficient funding to purchase land and develop a new park. The city manager informs you that the money can only be used to develop a new park and it may not be used to expand existing park facilities. As the new GIS project manager for the city, it is your responsibility to recommend a few suitable sites for a new park in the city. Your recommendation for siting this new park will be discussed at a city council meeting and you will have to explain the decision-making process to the public.

1) Describe (list) the variables (GIS data layers) that you would incorporate into a spatial model (site suitability model) and 2) briefly explain why these layers are relevant? Assume that you have access to any GIS data layers that you might need.
GPS Receivers
- there are many GPS receivers on the market today
  - some receivers are relatively inexpensive (recreational grade receivers)
  - and some are very costly (mapping and survey grade receivers)
  - the main difference is related to the quality of the GPS receiver and its capabilities
- mapping and survey grade receivers run on the Windows Mobile operating system
  - in essence, these receivers are ruggedized mobile computers (with a built-in GPS receiver)
  - this allows the user to load specialized GPS data-collection software
- most mapping and survey grade receivers are also capable of real-time differential correction

Field Mapping with GPS

Online Planning Resources
- to capture high-quality GPS data it is important to collect the data under the best field conditions
  - during the course of a day, the PDOP will vary as the arrangement of satellites varies in the sky
    - when the PDOP is low – the accuracy of GPS field data will be enhanced
    - when the PDOP is high – the accuracy of GPS field data will be diminished
  - thus, it is important to plan your field work to coincide with the best conditions (low PDOP)
  - and these conditions are quite predictable given that the orbit of each satellite in the system is known
- those who operate and track the satellites in a GNSS can predict the position of each satellite well into
  the future and this positional information is compiled in a GPS almanac
- In order for your GPS to work, whenever it connects to a satellite, the GPS downloads the almanac information
  - the GPS almanac provides the number and position of visible satellites for any geographic location in
    the world and any date in the future

GNSS Planning Online (Trimble)
- a web site that provides important information that can be used to plan field data collection
  - the URL for the web site is: http://www.trimble.com/GNSSPlanningOnline

  - the user specifies a location and date where the GPS field data will be collected
  - the planning tools provide information about the quality of the GPS signal at that location over time
  - the online planning tools include:
    - Settings (user location and date of planned GPS data collection)
    - Satellite Library (user can select the GNSS to display, e.g. GPS or GLONASS)
    - Elevation (graph of each satellite’s elevation above the horizon over time)
    - Number of Satellites (histogram showing the number of visible satellites)
    - DOPs (graph showing how the Dilution of Precision varies over time)
    - Visibility (plot of the duration of each satellite’s visibility)
    - Sky Plot (position and time trail for each visible satellite)
    - World View (position and time trail plotted on a world map)
    - Iono Map (world map showing the intensity of the ionosphere interference)
    - Iono Information (plot of Total Electron Content over time)

Field Data Collection Software

1) GPS Toolbar in ArcMap
- the GPS toolbar is accessed through the main menu in ArcMap
  - on the main menu bar, select Customize > Toobars > GPS
- the toolbar allows the user to:
  - connect a GPS receiver to a laptop
  - collect GPS coordinates and
  - display these coordinates on a map inside the ArcMap data frame
2) TerraSync
- Trimble’s mobile field mapping and data collection software
- designed to work with Trimble GPS receivers running the Windows Mobile operating system
- will also work on any other Windows Mobile or Tablet device
- allows the user to capture and edit GIS data in the field
- designed as a series of windows to provide control over the GPS receiver and data collection process
  - Map (allows the user to see the GPS data overlaid on a GIS layer or background image)
  - Data (allows the user to manage the data in separate files and create data dictionaries)
  - Navigation (allows the user to navigate to known locations)
  - Satellite Status (allows the user to download an almanac and view the status of GPS satellites)
- Set-up functions
  - GPS (allows the user to establish a minimum PDOP for data collection)
  - Real Time (allows the user to connect an antenna to receive differential corrections)
  - Coordinate System (allow the user to specify datums and coordinate systems)
  - Units (allows the user to specify the units of distance, area and velocity calculations)
  - External Sensors (allows the user to connect laser rangefinders)

3a) ArcPad
- Esri’s mobile field mapping and data collection software
- like TerraSync, ArcPad is designed to run on Windows Mobile or Tablet devices
- allows the user to capture, edit and analyze GPS data in the field
- can be used as a stand-alone system for field data collection
- or as part of a multi-user enterprise system (with ArcSDE)
- ArcSDE allows users to check out data from a RDMS (e.g. Microsoft SQL), edit the data in the field, and check the data back in at the end of the day
- the ArcPad interface works in a manner that is similar to ArcMap
  - users can add data layers from a variety of sources:
    - shapefiles, feature classes, raster layers and imagery
  - also includes many standard GIS tools:
    - turn layers off and on, - pan and zoom the map, - navigate to features,
    - capture GPS coordinates, - add attributes, - edit features
    - identify, select and query, - symbolize and display

3b) ArcPad users have the option to add the GPS Correct extension field data collection
- GPS Correct is a Trimble software product designed as an extension to ArcPad
- provides more control over your GPS receiver within ArcPad
- the extension adds some of the same functionality found in TerraSync
  - specifically, GPS Correct includes the Satellite Status and Set-up functions

4) Esri Collector for ArcGIS
- not a professional grade GPS data collection system – but a very useful app
- allows user to collect field data on a smartphone (either iOS or Android)
- must have a subscription to ArcGIS Online because data and maps are stored in the cloud
- download maps and use GPS to create and edit features

Post Processing Software for Differential Correction
- in most mapping applications we don’t need “real-time” differential correction of GPS coordinates
- most often, GPS field data are corrected back in the office using “post-processing” techniques

Pathfinder Office (Trimble)
- provides differential corrections to improve the quality of GNSS data collected in the field
- GPS data collected by the rover (rover files) are corrected using GPS data recorded at a base station
- base station files can be downloaded from any number of sources, including the Coast Guard or TxDOT
- Pathfinder Office provides support for both GPS and GLONASS post-processing
- also includes sophisticated data dictionary editor to ensure consistency between the field and the office
- overall, post processing provides a measure of quality control to GNSS data before export to a GIS
**ArcGIS Extensions**
- recognize that there are dozens of extensions to ArcGIS
- most of these extensions add tools to ArcToolbox and a toolbar to the ArcMap interface
- all of these extensions are designed to add more functionality (tools) to the core software
- some extensions are developed by Esri - some are developed by other software developers
- some extensions are available as a free download - some extensions require a software license
- examples include: Spatial Analyst, 3D Analyst, Geostatistical Analyst, Network Analyst, Tracking Analyst
  Survey Analyst, Business Analyst, and Military Analyst

**Using ArcGIS Extensions**
- to use licensed extensions, you must first enable the extension license
- to do so, you select Extensions from the Customize pull-down menu on the ArcMap menu
- this will open the Extensions dialog box showing all of the licensed extensions that you have available
- check the box next to the extension to enable the license and make the extension available for use
- once a licensed extension has been enabled, the next step is to turn on the extension toolbar
- to turn on an extension toolbar, select Toolbars from the Customize pull-down on the ArcMap menu
- this will load the extension toolbar which can then be docked on the ArcMap interface window

**Spatial Analyst**
- Spatial Analyst is an ArcGIS extension designed to work with raster data - especially digital elevation models
- the major functions are accessed through ArcToolbox > Spatial Analyst
- in lecture I demonstrated the use of several important Spatial Analyst tools:
  
  **Distance** - used to create a continuous raster distance surface from point, line or polygon features
  - you can also create an direction surface and allocation surface
  (a similar tool for vector data creates Thiessen polygons)

  - to create a distance surface, ArcGIS calculates the distance to the nearest point, line or polygon
  - in this example, the grid cell values are the distance to the nearest point (selected west Texas cities)

  ![Distance](image)

  - to create a direction surface, ArcGIS calculates the direction to the nearest point, line or polygon
  - in this example, the grid cell values are the direction to the nearest point (selected west Texas cities)

  ![Direction](image)
- to create an allocation surface, ArcGIS allocates cells to the nearest point (creates Thiessen polygons)
- in this example, the grid cells values are feature class codes corresponding to the nearest point

Density - used to create a continuous raster density surface from point or line features
- for a density surface, ArcGIS calculates the density of points or lines per unit area
- in this example, the grid cell values represent the density of playa wetlands per square kilometer
- to calculate the density of playa polygons, we must first create the playa polygon centroids (points)
- then we calculate the playa density surface from the playa centroids

Interpolate to Raster - used to interpolate a continuous raster surface from sample point values
- Spline - applies a smooth spline function to calculate the value of interpolated cells
- to interpolate a surface, ArcGIS estimates values for all of the grid cells between points
- in this example, we used well measurements to estimate the water table surfaces in 2000 and 2008
Map Algebra – used to apply arithmetic or algebraic functions to raster surfaces
- the difference in water table elevation from 2000 to 2008 is calculated by subtracting one raster from another. The difference raster clearly shows areas in red where the water table is declining and areas in blue where the water table is not declining.

Surface Analysis - particularly useful set of tools used to analyze digital elevation models
- Contour (used to create contour lines from a DEM)
- Slope (used to create a slope map from a DEM)
- Aspect used to create an aspect map from a DEM
- the cell values in an aspect raster give the compass direction the slope is facing eg. blue cells face north

<table>
<thead>
<tr>
<th>digital elevation model (DEM)</th>
<th>aspect raster derived from DEM</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Digital Elevation Model" /></td>
<td><img src="image2" alt="Aspect Raster" /></td>
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</table>

- **Hillshade** used to create a shaded relief layer from a DEM. Can classify the DEM and overlay on a hillshade

<table>
<thead>
<tr>
<th>digital elevation model (DEM)</th>
<th>Shaded relief (hillshade)</th>
<th>classified DEM overlaid on a hillshade</th>
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</thead>
<tbody>
<tr>
<td><img src="image3" alt="Digital Elevation Model" /></td>
<td><img src="image4" alt="Shaded Relief" /></td>
<td><img src="image5" alt="Classified DEM" /></td>
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- **Viewshed** (used to create a visibility surface relative to one or more observer points
  - user specifies the location and height of observation points
  - output raster shows cell that are not visible from the observation points (pink) and cells that are visible to one or more observation points (light green).

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<th>digital elevation model (DEM)</th>
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<tr>
<td><img src="image6" alt="Digital Elevation Model" /></td>
<td><img src="image7" alt="Viewshed" /></td>
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