Global Positioning System

Prof. Dr. Safa A. Najim
IS Department
CS and IT College
1/7/2018

GPS

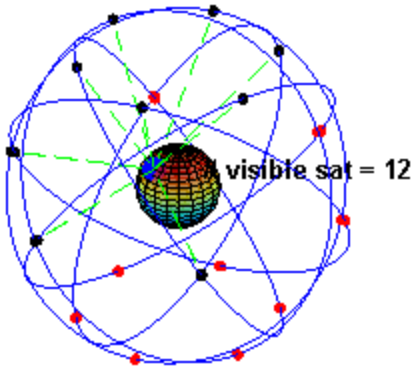
- Stands for Global Positioning System
- GPS is used to get an exact location on the surface of the earth, in three dimensions.
- GPS is a very important data input source, used for surveying, military operations, engineering, vehicle tracking, flight navigation, car navigation, ship navigation, unmanned vehicle guidance, agriculture, and of course, mapping
- For mapping, a GPS tells us “where” and allows us to input “what”

GPS

•GPS is a worldwide radio-navigation system formed from 24 satellites and their ground stations.

•Uses satellites in space as reference points for locations here on earth

•Ground stations help satellites determine their exact location in space. There are five monitor stations: Hawaii, Ascension Island, Diego Garcia, Kwajalein, and Colorado Springs.



Source: Wikipedia

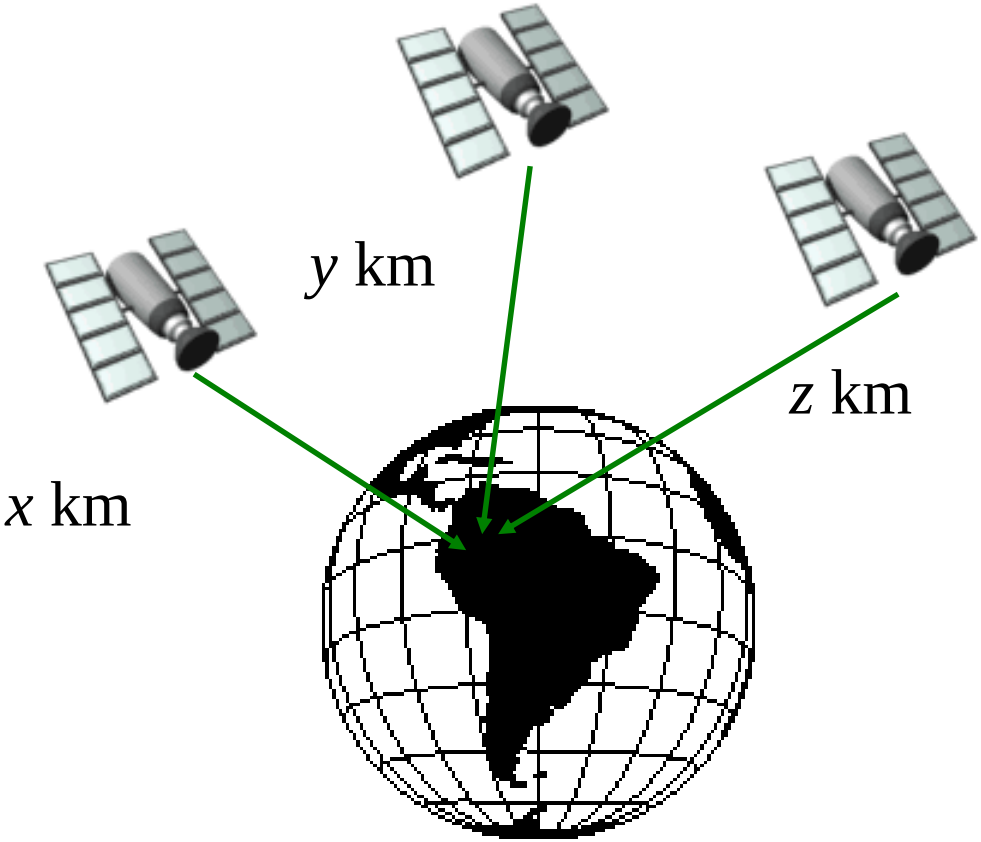
How does GPS work?

•GPS derives position relative to satellite "reference points," using triangulation

• The GPS unit on the ground figures out its distance to each of several satellites using the time it takes for a radio signal to travel to the satellite

•To do this, the exact position of the satellites at a given time, must be known; otherwise they can't serve as reference points

How does GPS work?



How does GPS work?

•We need at least 3 satellites as reference points to "triangulate" our position.

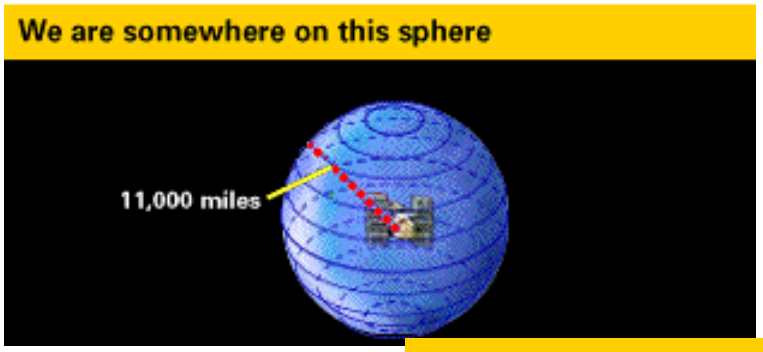
•Based on the principle that where we know our exact distance from a satellite in space, we know we are somewhere on the surface of an imaginary sphere with radius equal to the distance to the satellite.

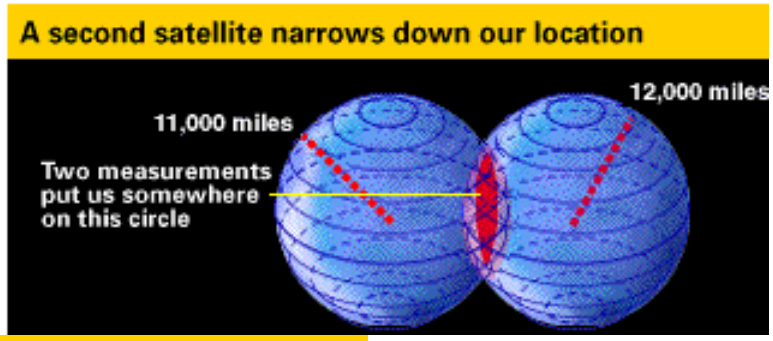
•With two satellites we know we are in the plane where the two intersect. With three or more, we can get two possible points, and one of those is usually impossible from a practical standpoint and can be discarded

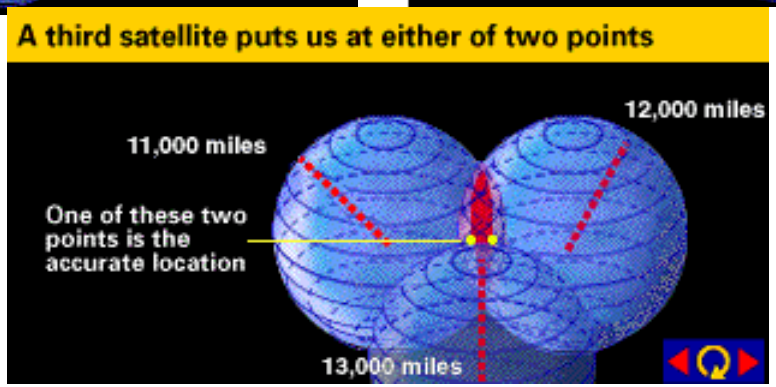
How does GPS work?

•Here's how the sphere concept works

• A fourth satellite narrows it from 2 possible points to 1 point







Source: Trimble Navigation Ltd.

How does GPS work?

- This method assumes we can find exact distance from our GPS receiver to a satellite. How does that work?
- Simple answer: see how long it takes for a radio signal to get from the satellite to the receiver.
- Since we know speed of light, we can answer this
- This gets complicated when you think about the need to perfectly synchronize satellite and receiver.
- A tiny error in synchronization can result in hundreds of meters of positional error

How does GPS work?

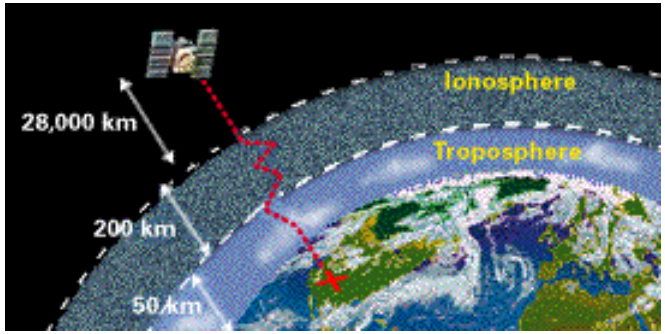
•The difficult part is measuring travel time, because the amount of time elapsed is tiny (about .06 seconds for an overhead satellite), and we require a way to know precisely WHEN the signal left the satellite

•To do this requires comparing lag in exactly similar patterns, one from satellite and one from receiver.

GPS sources of error

•Even after all this, there are still many factors that can generate errors and reduce positional accuracy

•One of the biggest error sources is the fact that the radio signal does not travel at the exact speed of light in different parts of the atmosphere as it does in the vacuum of space.



Source: Trimble Navigation Ltd.

•This can be partly dealt with using predictive models of known atmospheric behavior

GPS sources of error

•Signals also can bounce off features, like tall buildings, cliffs and mountains, resulting in “multipath error,” where a direct signal hits, followed by a bunch of “bounced” signals which can confuse the receiver.

•Good receivers have algorithms that can deal with this by determining what counts as a multi-path signal and choosing the first one as the signal to use

•There are other errors as well, resulting from things like ionospheric distortions and satellite inaccuracies

GPS Uses

- Trimble Navigation Ltd., breaks GPS uses into five categories:
  - Location – positioning things in space
  - Navigation – getting from point a to point b
  - Tracking - monitoring movements
  - Mapping – creating maps based on those positions
  - Timing – precision global timing
- You can learn about all these applications at these web links, but we mainly care about mapping

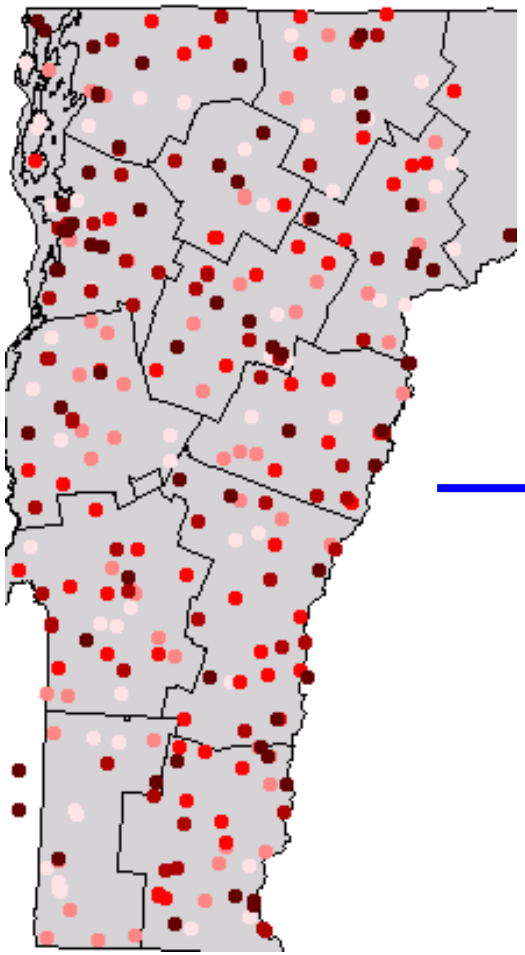
Introduction to Interpolation

What is interpolation?

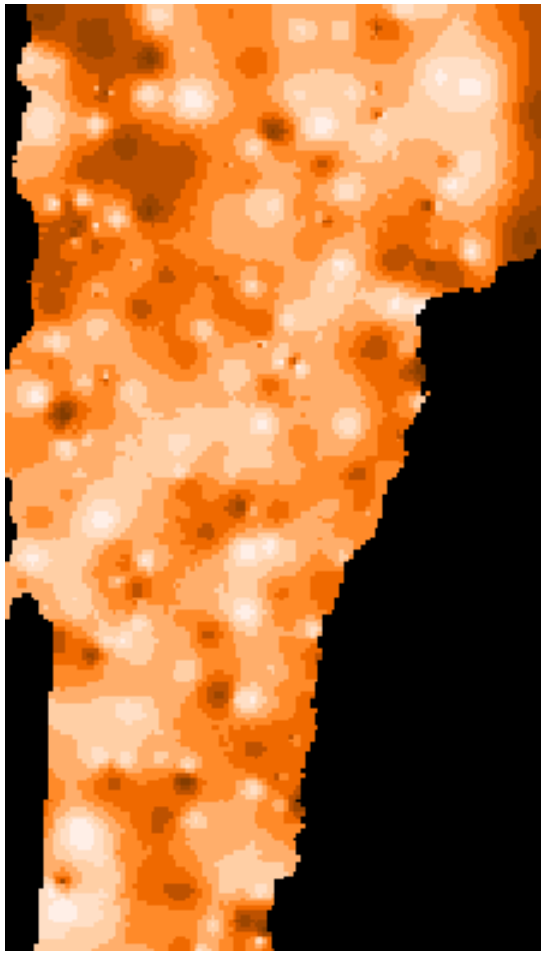
1. Resampling of raster cell size
2. Transforming a continuous surface from one data model to another (e.g. TIN to raster or raster to vector).
3. Creating a surface based on a sample of values within the domain.

What is interpolation?

- Let say we have our ground water pollution samples

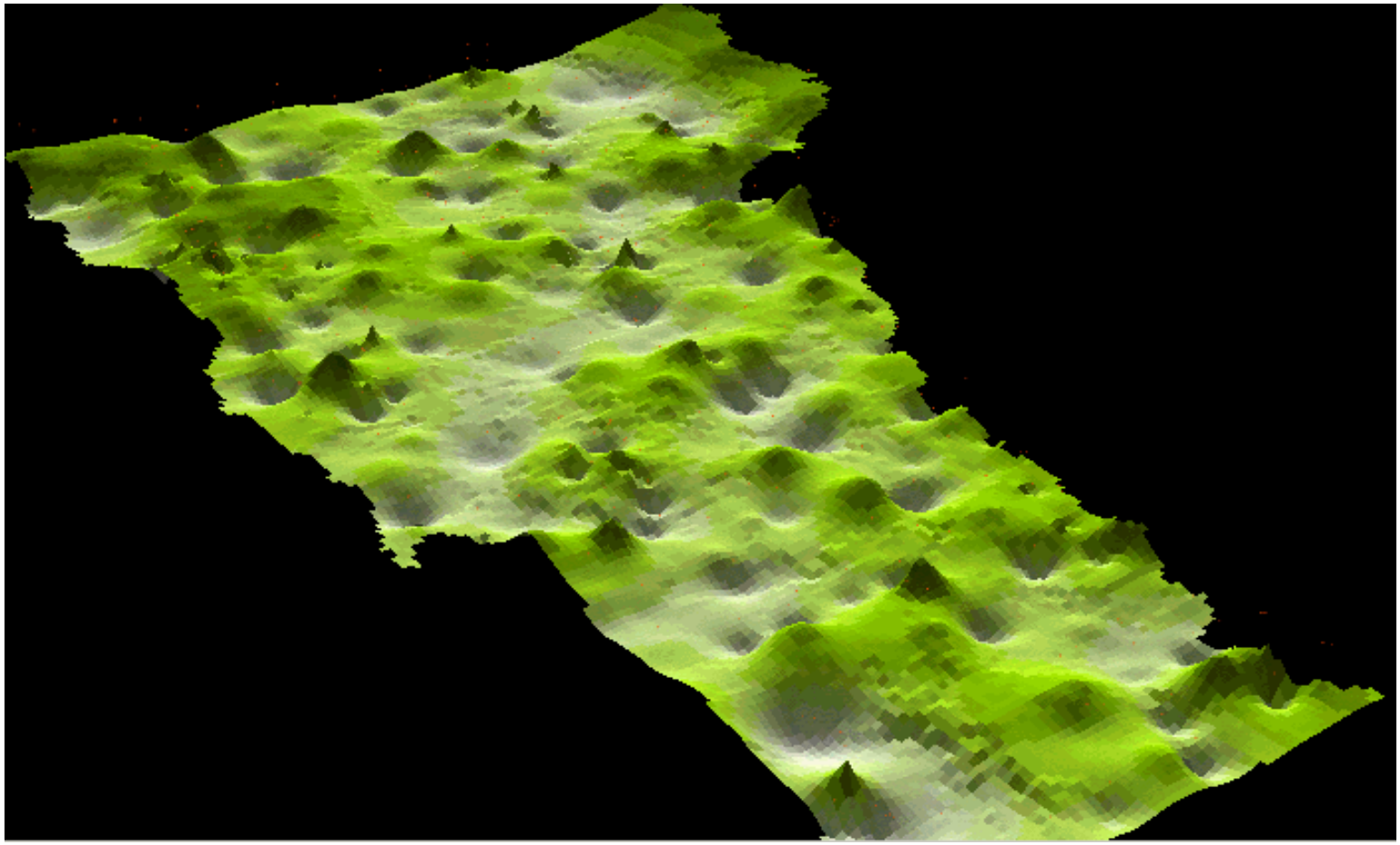


This gives us



What is interpolation?

- This can be displayed as a 3D trend surface in 3D analyst



Requirements of interpolation

- Interpolation only works where values are spatially dependent—that values for nearby points tend to be more similar

- Where values across a landscape are geographically independent, interpolation does not work

How does interpolation work

- Create or add point data which includes an attribute that will be used as a Z value

Inverse Distance Weighting

•IDW weights the value of each point by its distance to the cell being analyzed and averages the values.

•IDW assumes that unknown value is influenced more by nearby than far away points, but we can control how rapid that decay is. Influence diminishes with distance.

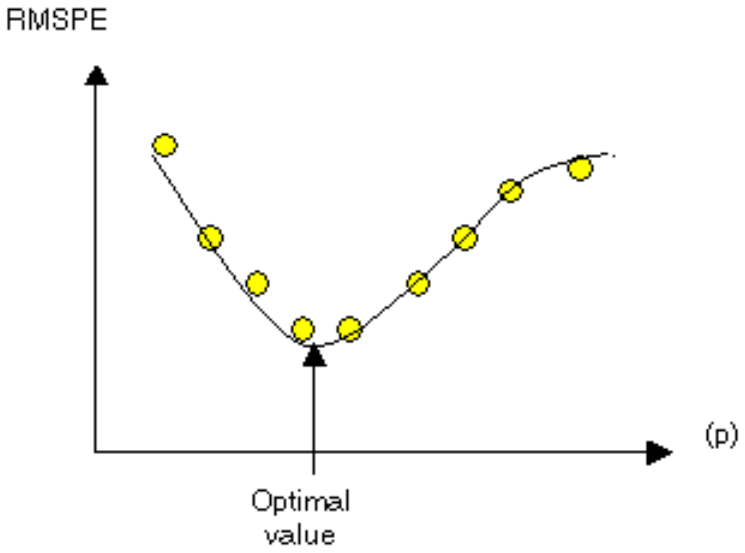
•IDW has no method of testing for the quality of predictions, so validity testing requires taking additional observations.

•IDW is sensitive to sampling, with circular patterns often around solitary data points

IDW-How it works

•What is the best P to use?

•It is the P where the Root Mean Squared Prediction Error (RMSPE) is lowest, as in the graph on right



•To determine this, we would need a test, or validation data set, showing Z values in x,y locations that are not included in prediction data and then look for discrepancies between actual and predicted values. We keep changing the P value until we get the minimum level of error. Without this, we just guess.