Geographic Computation in Perl

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Safety warning

If you think the world is flat,
this presentation will make your head explode.

Geography is BIG Today

- Maps on paper go back to ancient times
- Electronic age: natural move to web and mobile
- Geography is a deeper subject than just maps
- Any data pertaining to Earth's surface
  - Processing GPS data
  - Computing Great Circle routes
  - Geographic Information Systems (GIS)
  - Location Based Services (LBS)

Geospatial location data

- Locations on Earth can be specified by
  - Latitude – angle north/south from equator to poles
  - Longitude – angle east/west from Prime Meridian
  - Altitude – height above/below mean sea level
- Altitude is omitted when using surface elevation
- Latitude and longitude are angles measured from the center of the Earth
- Geographic data is more correctly called geospatial data when broken down in this form

Earth is not a perfect sphere

- Earth is an ellipsoid: bulges out at equator
  - Centrifugal force from rotation causes this
- Geoid: mathematical models for Earth ellipsoid
  - Good models come from satellite measurement
- Coordinates must use the same geographic reference system
  - Otherwise comparing apples and oranges
  - WGS84 most widely used coordinate system today

Sources of Geospatial Data

- Data can be gathered by many sources
- Measured by professional surveyors
- Measured by satellite (remote sensing)
- Measured by professionals or amateurs by GPS
- Read from maps
- Geocoded from street addresses
- Computations relative to other data

Lots of angles in Geospatial Data

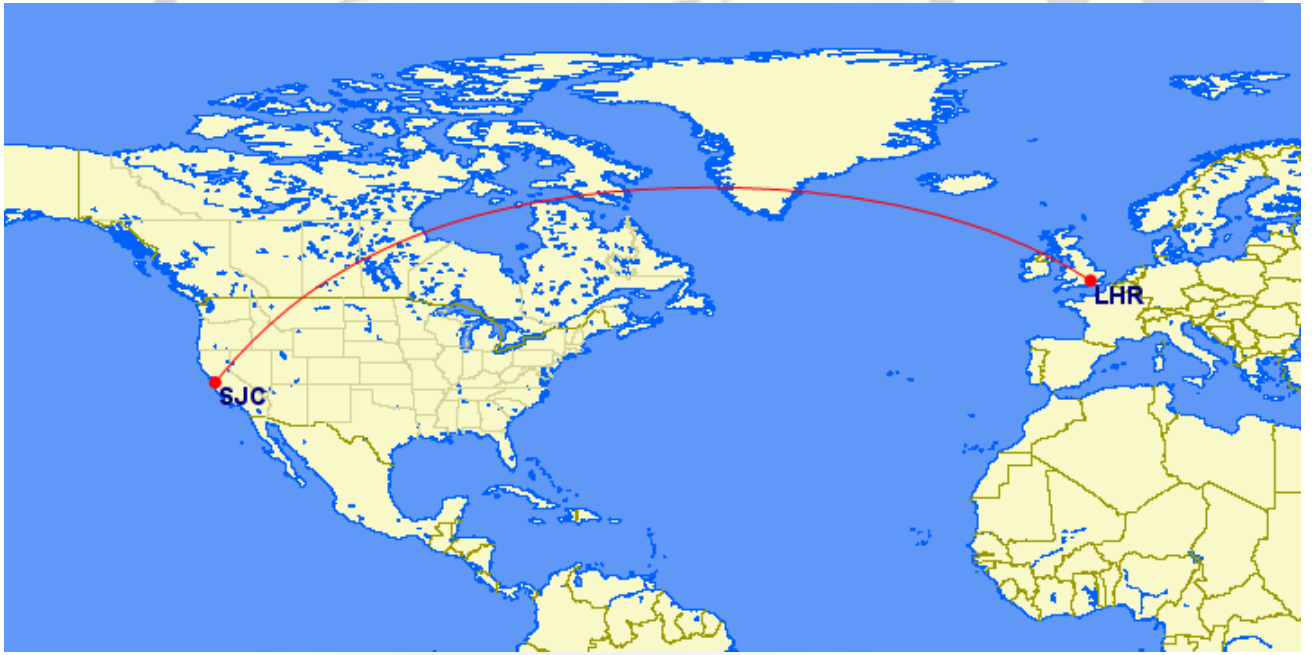
- This may come as bad news
  - There really was a use for that Trigonometry stuff some of you hated in school
- Many computations involve angles
  - Latitude and longitude are angles
- Manipulations use trigonometric functions
  - Useful to brush up on Trig to know what it's doing
- Trig functions use radians
  - So numbers in degrees must be converted first

Get Math::Trig Module from CPAN

- CPAN has many Perl modules to help with Trigonometry and Geospatial calculations
- Math::Trig has the basic foundation
  - deg2rad() - convert degrees to radians
  - rad2deg() - convert radians to degrees
  - All the basic Trig functions
  - A bonus: basic Great Circle calculations too
- http://search.cpan.org/search?query=Math%3A%3ATrig

Great Circle Routes

- Great Circle: direct route over Earth's surface
  - Along a line that would go around the sphere
  - i.e. from San Jose to London crosses Greenland



Map generated by the Great Circle Mapper - copyright © Karl L. Swartz. http://www.gcmap.com/

Great Circle Computations

- Useful for mapping and navigation
  - Distance between any two points on Earth
  - Initial course from one point to another
  - Points along the path between two points
  - Intersection of courses/lines/radials
  - Projecting a point at distance/bearing from a point
- Even over small distances, they can still be computed as angles from center of the Earth

Great Circle Tools and Info

- Many formulas at Aviation Formulary site
  - by Ed Williams
  - http://williams.best.vwh.net/avform.htm
- Great Circle online mapping tool
  - by Karl Swartz
  - http://gcmap.com/
- O'Reilly's “Mapping Hacks” book
  - by Erle, Gibson and Walsh

Geospatial-related Perl Modules

- Perl modules with Great Circle functions
  - Geo::Calc
  - Geo::Track::Log
  - GIS::Distance
- Perl module front-ends to mapping sites
  - Geo::Google::StaticMaps – Google Maps
  - Geo::OSM::StaticMaps – OpenStreetMap
- Many more – use search.cpan.org to search

Examples

Two examples follow with Perl code that was actually used for geographic computation to solve real problems.

- *CanSat Search at Black Rock Desert*
  Perl script generated search area coordinates for a missing payload from a rocket launch
- *Balloon and tracking teams live APRS map*
  Perl script makes live tracking map of teams chasing a high-altitude balloon

Example 1
CanSat Search at Black Rock Desert

Location: Black Rock Desert, Nevada

Problem: Rocket launched, payload missing

- Soka University (Japan) students needed data
- AeroPac club knew rocket landing coordinates
- Turned to Stratofox Aerospace Tracking Team
- Transmitter batteries died before their contact
- I wrote a Perl script to generate a grid search

Perl Script to Plot Search Grid

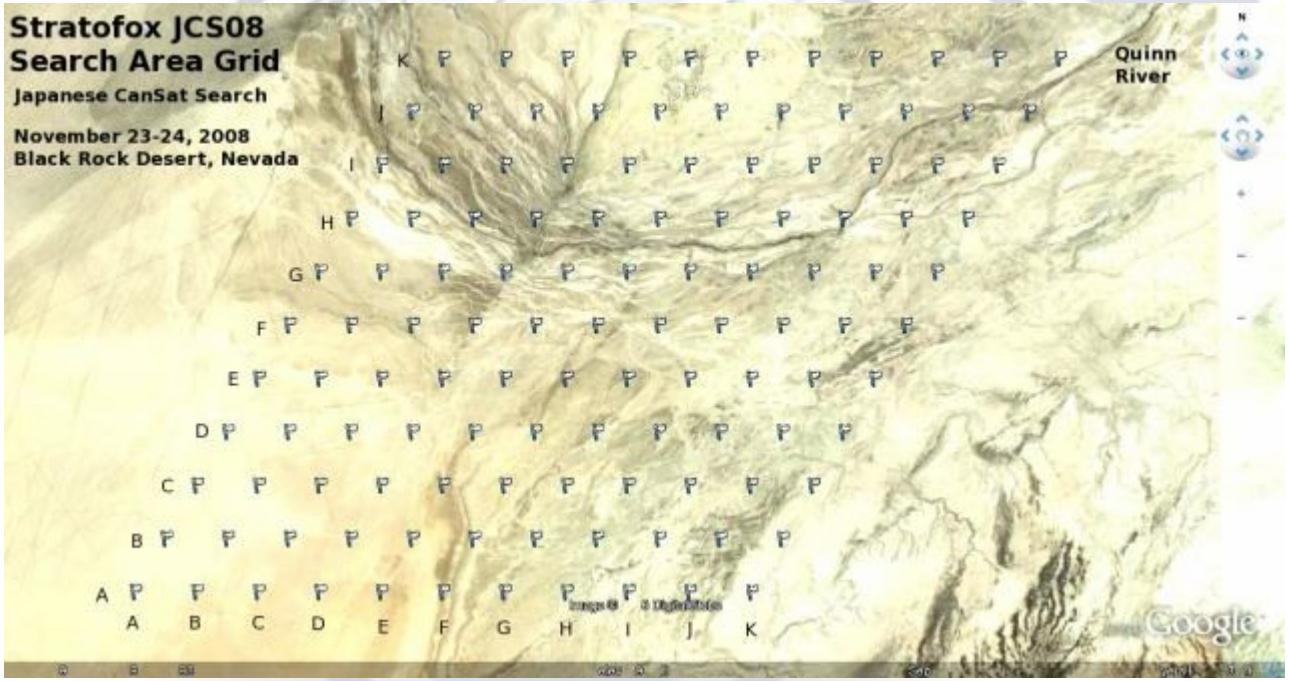
- Search area was 3x3 mile parallelogram
- Each side divided into 10 sections, 1584' long
- 10x10 loop projects each computed waypoint
- Command-line controls output to text or GPX
- “gpsbabel” turns GPX into many formats
  - Raw Garmin waypoint data for upload to GPS
  - KML for display on Google Earth

Projecting Search Grid Waypoints

- Nested loop: i = 0-10 over, j = 0-10 up
- Over = 270° heading, up = 330° heading
- Convert lat/lon from degrees to radians
- Use Great Circle projection formula
  - Compute intermediate point from i “over”
  - Compute final point from j “up”
- Convert new lat/lon from radians to degrees
- Code available at svperl.org with slides

Search Area Grid Map

Result of the script shown on Google Earth



Result: Success!!!

Expected to be worse than needle in a haystack

Payload found 2500' west of rocket landing site

Example 2
Live APRS Balloon Tracking Map

Problem: Display APRS tracking data for a balloon and our team who are tracking it

- APRS = Automatic Packet Reporting System, Ham Radio data protocol for transmitting your position
- The balloon and the tracking team all transmit their positions via APRS every minute or so
- Sites to display APRS data on a map don't do what we want

APRS.FI posted their Perl code

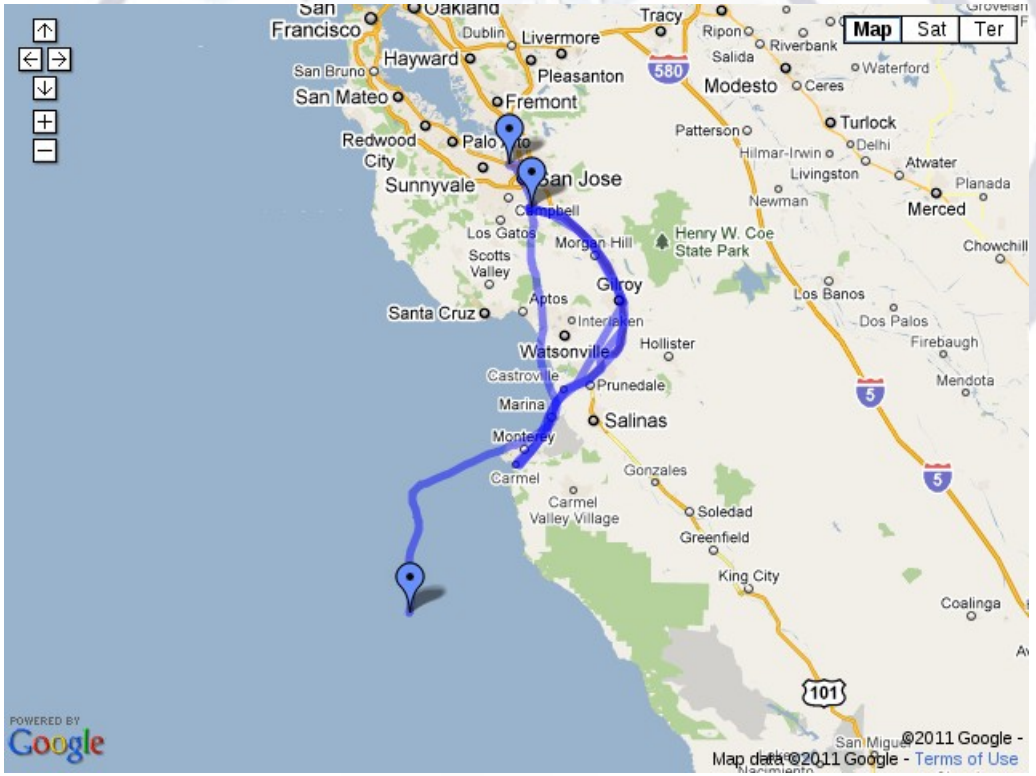
- Popular APRS mapping site APRS.FI uses Perl
- They posted Ham::APRS::FAP (“fabulous APRS parser”) on CPAN for all Perl developers
- You need Ham Radio license to transmit APRS
- You do not need Ham Radio license to receive APRS data
- Many volunteers forward APRS packets to APRS-IS servers on the Internet
- Everyone can subscribe to data streams there

Custom APRS Mapping Script

- Command-line parameter sets callsigns to log
- Subscribe to APRS-IS via Ham::APRS::FAP
- For each incoming line:
  - Parse line w/ Ham::APRS::FAP
  - Save data in a per-callsign list
  - Update output file in GeoRSS format
- Output file URL can be used in near real-time as an input to Google Maps
- Code available at svperl.org with slides

Balloon Chase on Google Maps

- A balloon on Feb 5, 2011 was lost in the ocean
- Teams chased it until Carmel – others watched



What else can you do?

- Your imagination may be your only limit
- Get a Google Maps API key and you can embed Google Maps into your web pages
- Calculate air-mile distance of a trip you took
- Process satellite data downloaded from NASA
- What do you want to do?
- Post your new modules on CPAN!