Project 1 - GPS Data Visualization and Convex Optimization

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Write-up your results, with the following information in it. (10%)

a. Background section (three or four paragraphs), with references. Discuss the background of GPS: When did GPS come about? How many satellites are there? What other relevant details should we know about GPS? What else did you find out that is interesting about GPS?

The GPS project was launched by the Department of Defence(DOD) in 1973 for military applications and became fully operational in 1995. Civilian use for GPS services allowed in the 1980s. There are 24 satellites used for providing the GPS System. 72 satellites have been launched but not all remain operational.

There are numerous factors that affect the quality of GPS readings. Signal Strength, Number of Satellites play a role into quality. Dilution of precision is specifies the degree of degradation of the GPS positioning accuracy.

The newest 2018 GPS receivers which use the L5 frequency can identify a device around 30 mts. The GPS System is wholly an American endeavors and White house administrations in past have denied used to certain parties. There are other countries like China, Russia, Japan that are also developing their own GPS systems.

References:

https://www.nasa.gov/directorates/heo/scan/communications/policy/GPS_History.html
https://en.wikipedia.org/wiki/Global_Positioning_System
https://en.wikipedia.org/wiki/List_of_GPS_satellites

b. Describe how you wrote your program. What program pattern did you use? Did you hold all the information in memory at once? Did you parse all of the files at once?

The general algorithm is:

1. Read in data line by line, each line is stored in a class that acts like a data structure
2. Lines that contain errors are ignored. Some values like Date that contain errors are fixed
3. Make a Path Object from all Lines
4. Remove Redundant Points from data(details specified later)
5. Identify all the left turns in route(details specified later)
6. Identify all stops in route, maintain a list all stops ever
7. Calculate Cost of every path to find the optimal path(details specified later)
8. Make a KML file for every path that shows all stops and left turns for route

Object Oriented Concepts is used here. Every Line (every GPS Point) is an object. All Lines from a path are stored in a GPS Path Object.

All information is held together in memory. All files are parsed together sequentially.

c. How did you define a left-hand turn, and then detect it in the data? What problems did you find with the approach? Did you have to do any noise removal or signal processing?

Left turns are identified from a special subset of data. This subset of data is free of redundant points. Redundant points in this context are points which are within a proximity of 0.5mts off each other. The points that are retained are at least 0.5 meters or farther from each other.

Then Left turns are identified using angle between the points. The angle between two points is defined as:

$\Delta\varphi = \ln(\tan(lat_B / 2 + \pi / 4) / \tan(lat_A / 2 + \pi / 4))$

$\Delta lon = abs(lon_A - lon_B)$

bearing : $\theta = atan2(\Delta lon , \Delta\varphi)$

Source: https://www.sunearthtools.com/tools/distance.php#txtDist_3

Values between 30 and 75 of bearing are accepted

Then these values are further cleaned.

We maintain all the points where time between 2 points is at least 60 seconds. We choose only those points that are 60 seconds away from each other.

PS: There is another way to identify change using tracking angle. Value decreased when left turn is taken and values increase when right turn is taken. Sudden turns result in sharp changes for data. I could not explore this option.

d. How did you define a stop, and then detect it in the data? What problems did you need to overcome?

We check two conditions:

- We Check if current speed is less than 40% of average last 5 speed values
- All speeds below 0.1 MPH are also dropped

After some trial and error, the numbers of 40% and 0.1 MPH were chosen**.** All Stop Points have speed less than 8MPH.

The process to identify the most relevant speeds for stops took some time and effort.

e. Describe what the "best" trip to work was. Which file?

The best trip was ZIAA_CTU_2018_10_10_1255.txt. The cost function for the trip was calculated as Cost = (Travel Time (mins) / 30 (mins)) + 1⁄2 (Maximum Velocity (mph) / 60 (mph)). The least cost is 1.56154

f. A screen capture of image of the best track or trip to work, with annotations if you did them.

Yellow Path - Best Path
Red Pin - Stop Signs
Yellow Pin - Left Turns

g. A summary conclusion of what you learned overall, and how this might be useful for some commercial application.

I learnt a lot about using GPS data and formatting it as a KML file.
There are tremendous problems that can be solved using data. Analysis of data will assist delivery companies. The path, speed optimization can also help self driving cars save energy.