GPS Data Visualization and Convex Optimization

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?

Meaning and History:

Global Positioning System (GPS) was originally called the Navstar GPS.
The idea started after the launch of Russia's artificial satellite Sputnik when two scientists found that the frequency of the radio signals changed when the satellite moved closer and away caused by the 'Doppler Effect'. Based on this idea the Naval department of America created the satellite navigation system to locate the submarines.

In 1973, United States of America launched the first GPS project initially only for the Military and later in 1995 for the civilians as well. Currently, there are 31 operational satellites for GPS of which at least 24 satellites are available 95 % of the times. There are 3 more satellites which are decommissioned and can be activated if required.

Working:

The GPS receiver uses the process called Trilateration to find the exact location using three satellites. Thus, you can see at least four satellites at a time at a location, where the fourth satellite is used in case of emergency. Thus, More the number of satellites, better the accuracy.

VPS:

Google has recently announced Visual Positioning System (VPS) which is a new revolution to GPS. VPS combines the live camera to the positioning of the location to give better understanding of the directions and exact location.

References:

1. http://www.physics.org/article-questions.asp?id=55
2. https://en.wikipedia.org/wiki/Global_Positioning_System
3. https://www.pcworld.com/article/2000276/a-brief-history-of-gps.html
4. https://www8.garmin.com/aboutGPS/
5. VPS: https://www.youtube.com/watch?v=4-Fr9BFHluc
6. https://appleinsider.com/articles/18/05/08/google-maps-to-get-augmented-reality-vps-other-improvements

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?

I used method B. from the slides as my programming pattern.
I created a function to parse a file and called the function on all the data files separately.

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?

I used the concept of 3-D cross-products to define a left turn.
Here the three vectors are:
X: Latitude
Y: Longitude
Z: Zero Vector

Vector_1_X = X[0] – Z[0]
Vector_1_Y = Y[0] – Z[0]
Vector_2_X = X[1] – Z[1]
Vector_2_Y = Y[1] – Z[1]

Then, the Cross Product = Vector_1_X * Vector_2_Y - Vector_1_Y * Vector_2_X
If the Cross Product is > 0, then it is a left turn.
If the Cross Product is < 0, it is a right turn.

Now. For our problem, we also have a tracking angle. I have used tracking angle and speed to detect a turn.
Summarizing, I have defined Left turn if the tracking angle is > 80 degrees, speed < 10 mph and time < 1 min if the cross product is greater than zero.

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

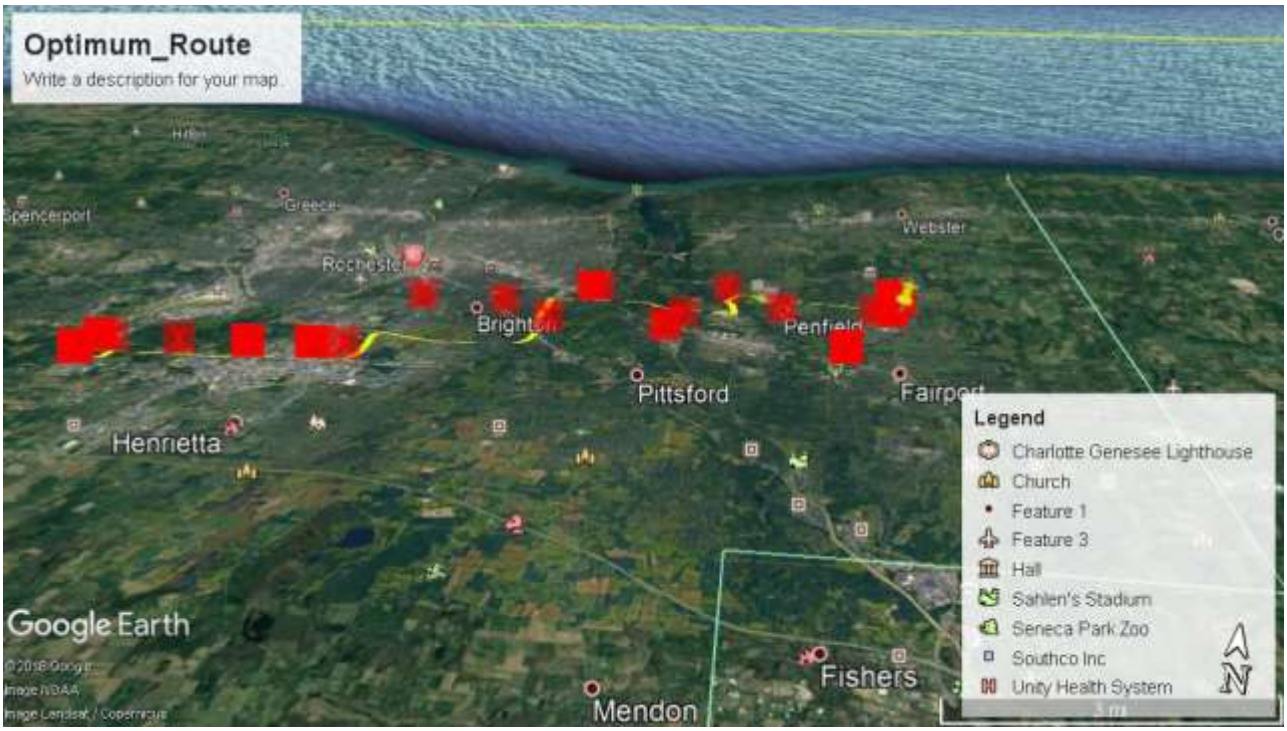
I defined the stop as a point at which the Latitude and Longitude were same with a waiting time of at least 5 secs and speed less than 8 mph.
This algorithm returned redundant points for stops. I used the unique values as the stops.

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

The best trip to work I got is 'ZIAA_CTU_2018_10_10_1255.txt'

The number of stop lights for the best route are: 7
The Cost function values (Objective function, Regularization function,Total cost) are:
[1.0628888888888888, 0.49868, 1.5615688888888888, 'path_7']
The best Path is : path_7 with cost function = 1.5615688888888888

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



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

I learned to generate KML files and to visualize it in Google Earth.

Also, this project was a good revision of geography (Earth Position Measurements) and math (dot and cross product) and its wide and important real-world application in GPS to detect directions and Stops.

Applications: We know that GPS is widely used for Courier/delivery services by Major companies like USPS, FedEx, DHL, UberEats to optimize route (distance, fuel cost, time etc.) and to track the delivery of products.

GPS is extensively used by Bike/Car Rentals companies to monitor and ensure safe returns.

Some companies also use Employee GPS tracking system to track time at location of their employees while they are on-site or at client's site to know at which job site the crew is and for how long. This is further used to fill in automated time-sheets, payroll integration and Productivity Monitoring.

Other References:

1. https://www.movable-type.co.uk/scripts/latlong-vectors.html
2. https://stackoverflow.com/questions/3419341/how-to-calculate-turning-direction
3. https://www.geeksforgeeks.org/direction-point-line-segment/
4. https://grindgis.com/gps/50-uses-or-applications-of-gps