Finding the Optimized Initial Locations for Station-free ofo Bikes

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Introduction:

Transportation is a critical aspect of city planning. Public transportations such as bike sharing can make people's daily transit to work and school faster and easier. Hubway, Boston's public bike sharing system, has over 160 stations with over 1,600 bikes available for people to share.[1] While it has created convenience for people, it is not as convenient as a station-free bike sharing system such as ofo [2]. Ofo bikes can be be picked up or dropped off at any location where traditional bike parking is allowed. Because of its flexibility and inexpensiveness, it is quite likely that ofo will become popular and widely used in the city very soon. In this project, we focused on finding the optimized initial locations to place ofo bikes so that people can get easily transit between school and subway stations.

Dataset:

We collected 5 datasets from Analyze Boston, Hubway, and Data Mechanics.

1) Wards: Geospatial data for wards in Boston
   (https://data.boston.gov/dataset/wards)
2) Public Schools: Set of public schools coordinates in Boston
   (https://data.boston.gov/dataset/public-schools)
3) Non-public Schools: Set of non-public schools coordinates in Boston
   (https://data.boston.gov/dataset/non-public-schools)
4) Hubway Stations: Set of Hubway Station coordinates in Boston
   (https://www.thehubway.com/system-data)

5) Subway Stops: Set of subway stop coordinates in Boston (http://datamechanics.io/data/MBTA_Stops.txt)

Methodology:

This project tries to find the optimal locations to place the ofo bikes such that each school either has a subway station within x miles or has a subway station with ofo bikes within y miles and the number of places to put the bikes are minimum. (x = the average distance between each school and its closest subway station; y = the largest of all distances between all school-subway pairs)

1). For each school, find its closest subway station and the distance between them by using data transformations.
2). For each school, find its closest hubway station and the distance between them by using data transformation.
3). Use z3 solver to find the set of assignments that satisfy our constraints above
4). Loop over different number of bike placement locations to find the optimal assignment
5). Visualize each school and its assigned subway station, which may or may not have ofo bikes, by using Python flask server and leafletJS.

Visualization

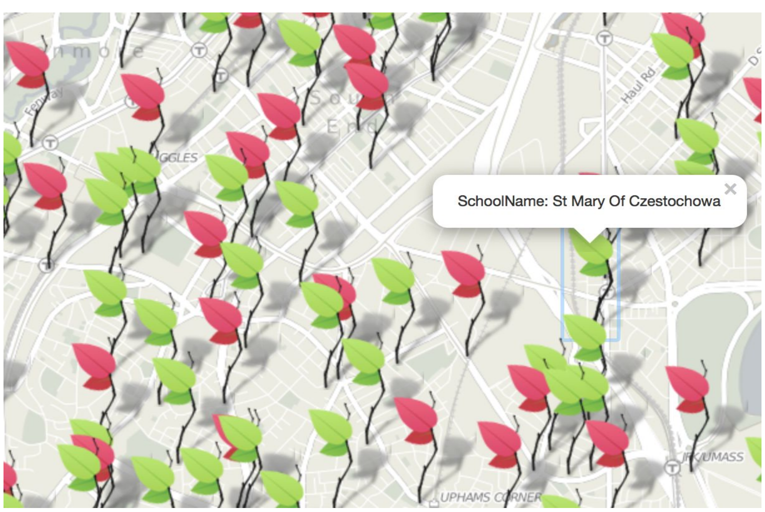

Figure 1. Map of all schools and subway stations

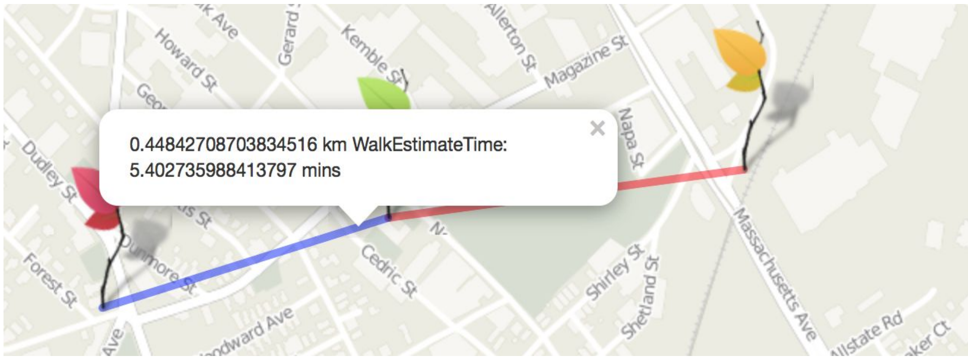

Figure 2. Comparison between original and new assignments

By using the interactive client-server application, people can get a list of all schools and subway stations showing on the map. They can also search for schools, subway stations, hubway stations, school to its closest subway/hubway station, school and its newly assigned subway station (may be with or without ofo bikes), as well as compare old and new results.

Results & Conclusion

Table 1. Comparison between original assignment and new assignment				
	Average distance(km)	Standard deviation of average distance	Average time (mins)	Standard deviation of average time
School to Subway	0.1365	0.1042	1.7379	1.2476
School to Hubway	1.4930	1.9235	17.9889	23.1756
New Assignments	0.1443	0.1036	0.5586	0.4007

It can be seen from Table 1 that the new average distance between school and assigned subway station is much smaller than those between school and hubway station. However, the new average between school and assigned subway stations slightly increases from 0.1365 km to 0.1443 km because we are trying to minimize the number of placement locations for ofo bikes. At the same time, schools who have a subway station within certain distance to its closest subway station are excluded from this calculation. Therefore, other parameters should be considered in evaluating the model. For example, the average time it takes to transport between schools and newly assigned subway stations is 0.5586 minutes, which is about only 32% of the time you need to walk to subway station. As you can see, there is a great improvement in the cost of time for transiting between school and subway stations by using the ofo bikes. People can also access ofo bikes more easily than hubway.

However, people may want to get to different subway stations depending on which line of subway they want to take, which is not taken into account in this calculation. Therefore, there is still a lot of space for future works.

Future Work:

As you can see, having ofo bikes initially placed at the assigned subway stations can get people to school faster. However, in our assignment, we did not consider the population of each school and neighborhood, which could play a crucial role in the bike usage. At the same time, there are also other places such as restaurants and shopping centers that are quite crowded and have a lot of potential customers for ofo bikes. Therefore, future works should also consider those places and the people flows of those areas. Lastly, walking and biking distances should be calculated by finding an actual route instead of estimating it using straight-line distance on the map.

References:

[1] "Hubway." Boston.gov. January 30, 2018. Accessed April 30, 2018. https://www.boston.gov/departments/boston-bikes/hubway.

[2] "Ofo." Ofo. Accessed April 30, 2018. https://www.ofo.com/us/en.