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. ofo bikes can be picked up or dropped off at any location where traditional bike parking is allowed [2]. In this project, we focused on finding the optimized initial location to place ofo bikes so that people can easily transit between school and subway stations.

Dataset

Wards: Geospatial data for wards in Boston
Schools: Set of public and non-public schools coordinates in Boston
Hubway Stations: Set of Hubway Station coordinates in Boston
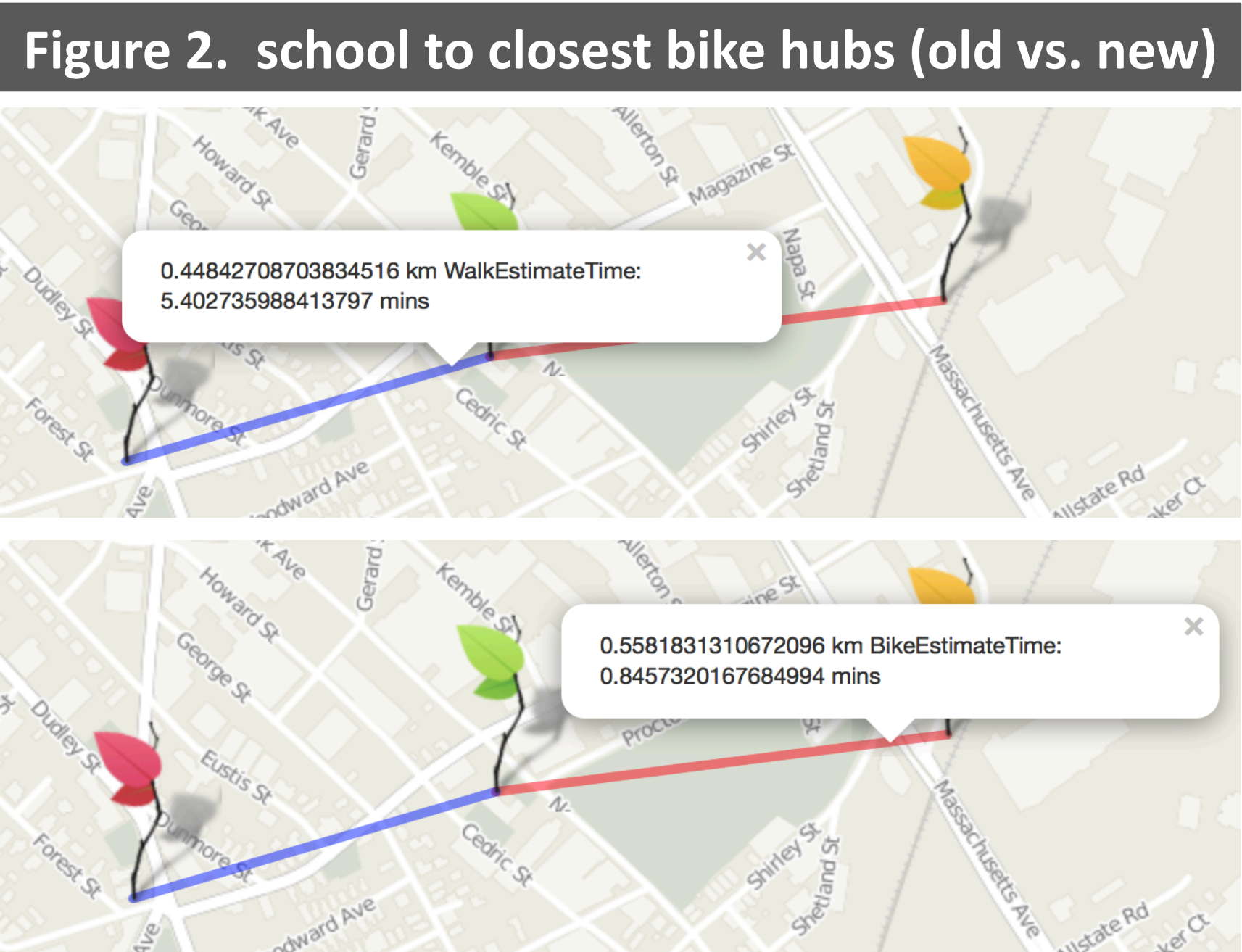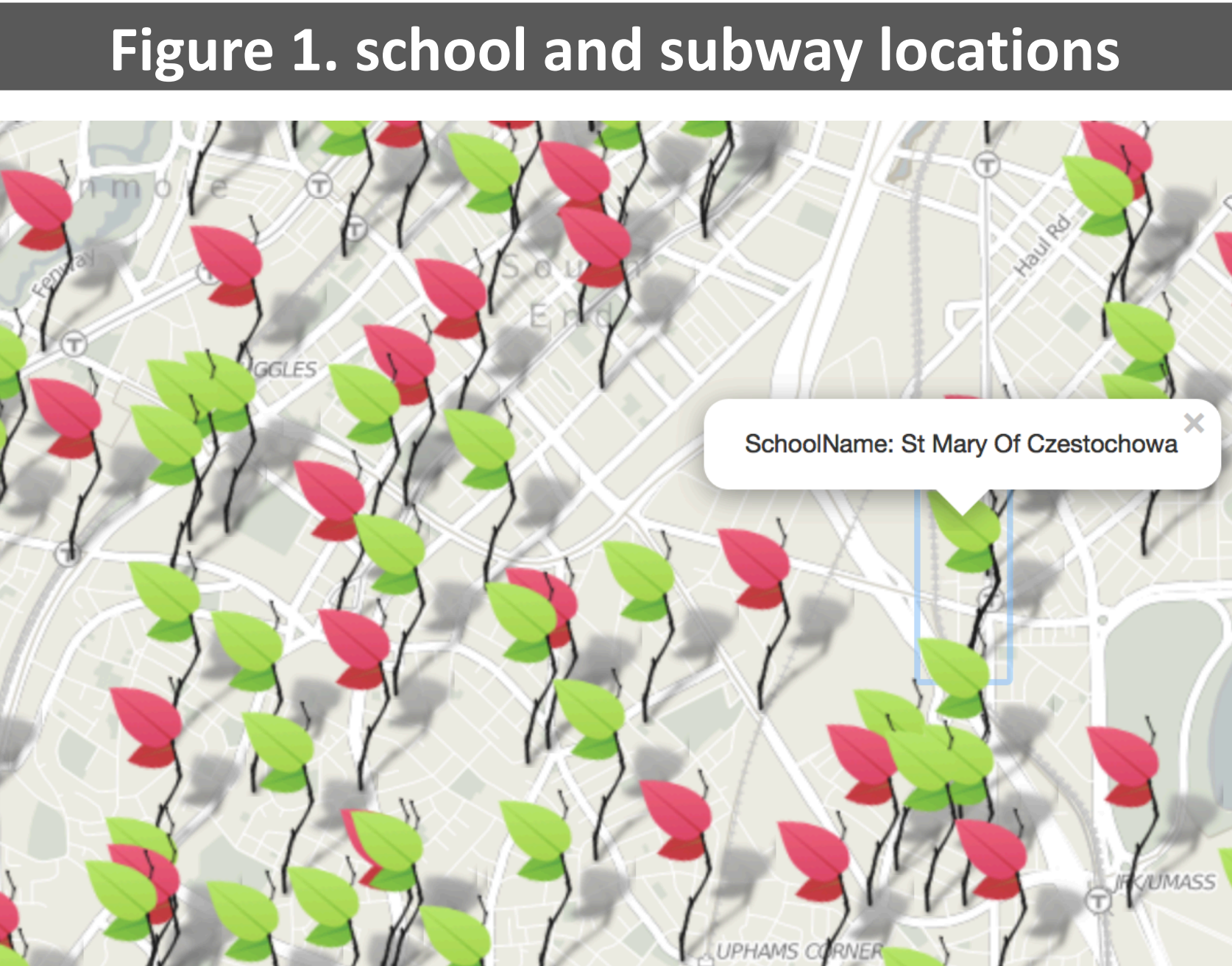Subway Stops: Set of subway stop coordinates in Boston

Methodology

We are trying 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.
1). Use the K-means algorithm to get list of potential subway stations for each school
2). Use z3 solver to find the set of assignments that satisfy our constraints above
3). Loop over different number of bike placement locations to find the optimal assignment
4). Visualize each school and its assigned subway station, which may or may not have ofo bikes, by using Python flask server and leafletJS.

Conclusion

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.

Figure 1. school and subway locations

SchoolName: St Mary Of Czestochowa

Figure 2. school to closest bike hubs (old vs. new)

0.44842708703834516 km WalkEstimateTime: 5.4027735988413797 mins

0.5581831310672096 km BikeEstimateTime: 0.8457320167684994 mins

Note: all distances are straight-line distances
          walking speed is assumed to be 0.083 km/min
          biking speed is assumed to be 0.258 km/min

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

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.

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