First insights into Boston as a 15 minute city

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Introduction

In response to COVID19, Boston, among 96 other cities in the C40, have committed to a "green and just recovery." Among many things, cities in the C40 have committed to making sure that all their residents have safe and green methods to access fundamental resources and amenities so that their cities are more resilient to future health crises. Such an idea is encapsulated by the "15 minute city" or a city where every resident has access to essential services and amenities within a 15 minute walk or bike ride. The 15 minute city is not a new concept as cities like Melbourne and Paris have already implemented measures to help promote equitable access. Boston is looking to start building a 15 minute city and thus, we are working with Boston's New Urban Development team to help start such development. We want to identify parcels that don't have access to amenities within a 15 minute walk/bike within the city of Boston and identify specifically who and where is Boston lacking. Ideally, we would like to identify zip codes or general areas of Boston that need further development of essential services to help advise future city planning. We have four key questions we want to answer:

1. What amenities in Boston belong to each of the six categories of essential amenities necessary for a 15-minute city?
2. What percentage of parcels are within 15 minutes of essential amenities?
3. Which areas of the city are underserved in terms of a lack of essential amenities, and which amenities are they missing?
4. What are the demographics of the underserved (non-15-minute) communities?

Methodology

We defined 6 different types of amenities: healthcare, commercial, social, food access, education, and recreation. The categorization of amenities is fairly intuitive. Healthcare encapsulates all of the hospitals and pharmacies and education includes schools and universities. Food access amenities consist of parcels that provide access to bulk food and does not include restaurants, cafes, etc. The latter do not tend to promote general food access and are placed under different categories. Recreational amenities promote general leisure and sport, which includes places like parks and gyms. Social amenities encourage interactions between people and emcompasses places like cafes, bars, and places of worship. Commercial amenities are the general "catch-all" for other amenities that are not strictly residential.

For reference, "spatial analysis" will refer to how we dealt with determining which amenities are close to each parcel. We performed two different types of spatial analysis which will be referred to as "simple" and "complex". For simple analysis, we first layered a grid on top of a map of Boston. For every residential parcel, we drew a circle around it with its radius being the distance that we estimated a person could walk 15 minutes for. We did not take into account streets, the Charles, or general spatial obstacles; We assumed a person could walk in a straight line from the residential parcel to each amenity. We then checked which types of amenities were present within that radius.

For complex analysis, we took street data into a network graph with the lengths as weights. For every street intersection, we made an ego graph with each of the connections being other street intersections that are within 15 minutes. We then took each residential parcel and amenity and assigned it to a street segment. We then assumed each parcel/amenity to be at either end of the street and assigned each parcel/amenity to an intersection. Using the corresponding ego graphs, we then checked each connection in the ego graph for a given residential parcel to see if it was connected to an amenity

Explanations of each directory in the Github repo:

All code can be seen here

Dependencies

- Jupyter notebook
- Pandas
- Numpy
- Os
- Folium
- pyproj

code

The preprocessing folder contains all the code that was used to clean the separate raw datasets. These programs span businesses, greenspaces, healthcare, schools, etc. The programs are a combination of both python and jupyter notebook files. These files output cleaned CSV files to datasets_clean.

The maps folder contains html files that are used for figures regarding our general spatial analysis.

The demographics folder contains the program we used for our demographic analysis of the general Boston area and the specific zip codes of interest. The maps folder within the demographics directory contains html files that visualize our demographics analysis.

merge.py is used to merge all of the cleaned datasets together, distance.py runs to the simple analysis, and distance_crawl.py will perform the complex spatial analysis.

dataset_ignore

The dataset_ignore folder is the folder that would have contained the raw datasets. We intentionally did not push these datasets to Github as they are generally large. Refer to the preprocessing code for raw datasets.

datasets_clean

Each of the cleaned datasets (that is the output of the preprocessing code) are within this folder and are generally self-explanatory. For instance, “pharmacies_sanitized.csv” contains cleaned data about pharmacies in Boston. Each of the cleaned datasets generally contain name, address, category, zip code, latitude, and longitude features.

The final merged dataset is called final_merge.csv in this directory. The features on it are name, zip, lat, lon, category, and address. Most of these are self-explanatory. lat and lon correspond to latitude and longitude respectively, address refers to street address, and category is amenity category. Each of the amenity datasets was standardized and concatenated to create this dataset.

Simple analysis discussion

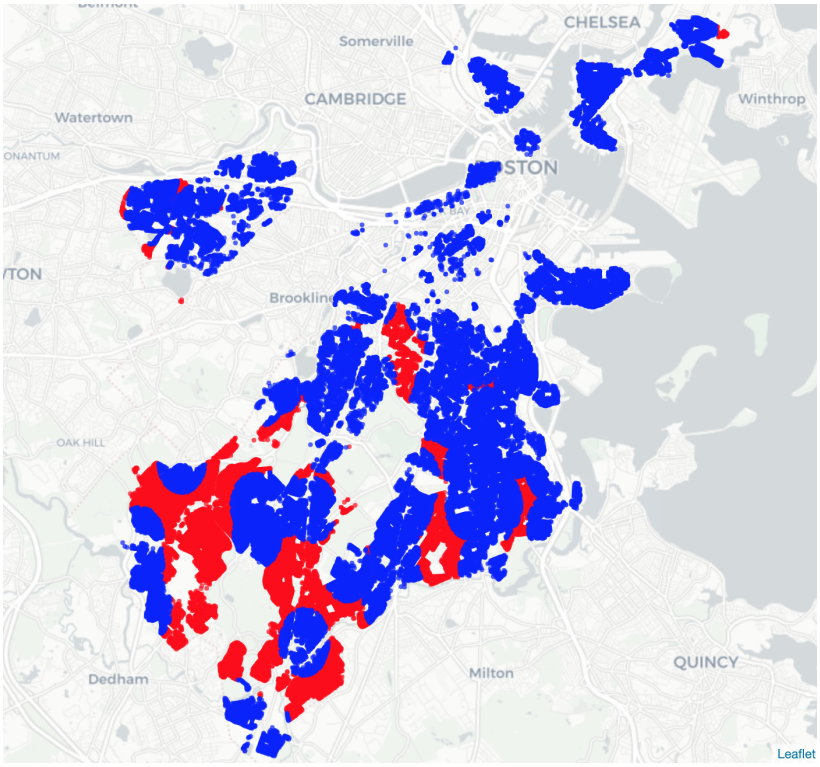


Figure 1: Visualization of Boston as a 15 minute city utilizing simple spatial analysis. Well resourced parcels, or parcels that are 15 minutes within at least 1 of each type of amenity, is visualized in blue. Under resourced parcels are colored red.

To be succinct, “under resourced” parcels will refer to parcels that are missing at least one type of amenity within its radius and “well resourced” parcels will refer to parcels that are not missing any amenity types within its radius. Through our simple spatial analysis, most of the parcels in the main Boston area are well resourced (Figure 1). Most of the under resourced parcels are further away from the main Boston area. Looking at each of the coverage of each individual amenity, most amenities covered most of Boston. Social amenities, however, were sparse and most of the under resourced parcels in Figure 1 are due to the lack of a social amenity (Figure 2). The social amenity was very lacking and was considerably smaller than the other amenities. Talks with Nayeli and Kat also revealed that we were missing some residential parcels in the main Boston area. In the complex analysis, we added the missing residential parcels and refurbished the social amenity.

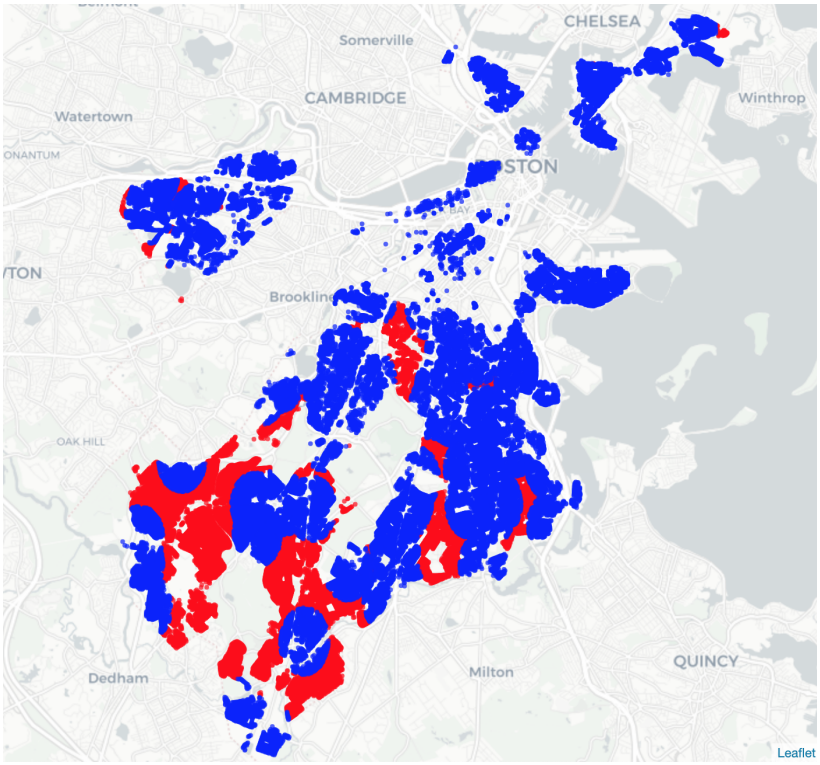


Figure 2: Visualization of which residential parcels are within 15 minutes to a social amenity utilizing simple spatial analysis. Figure 1 is strikingly similar to Figure 2, indicating that most of the under resourced parcels are likely due to missing a social amenity.

Complex spatial discussion

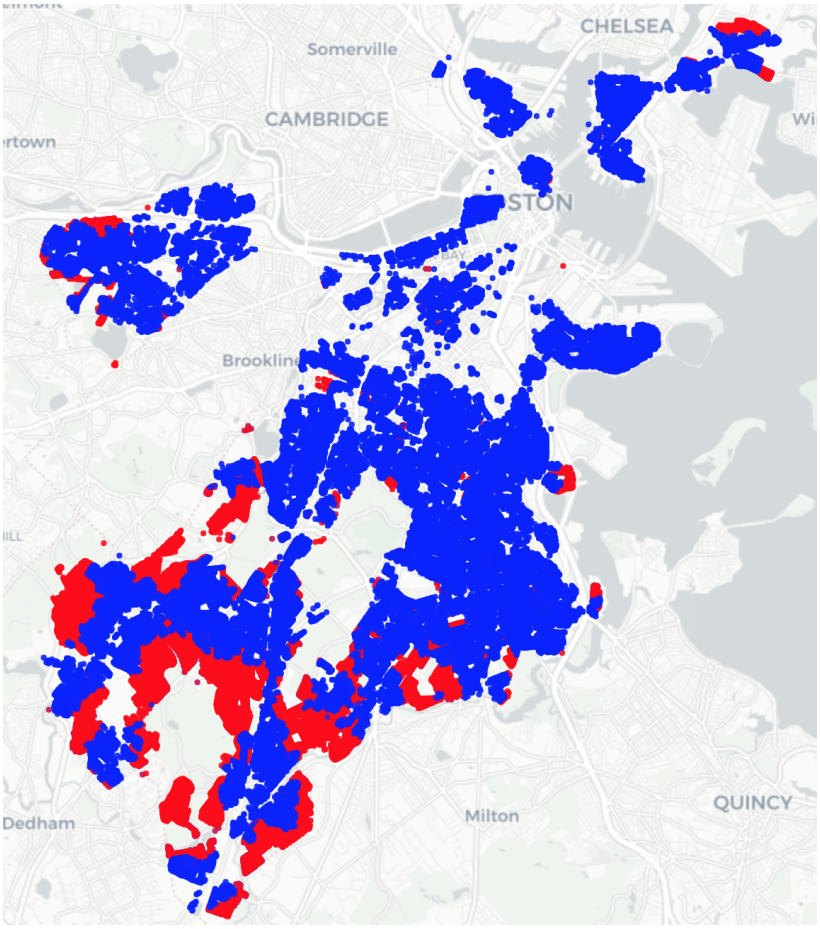
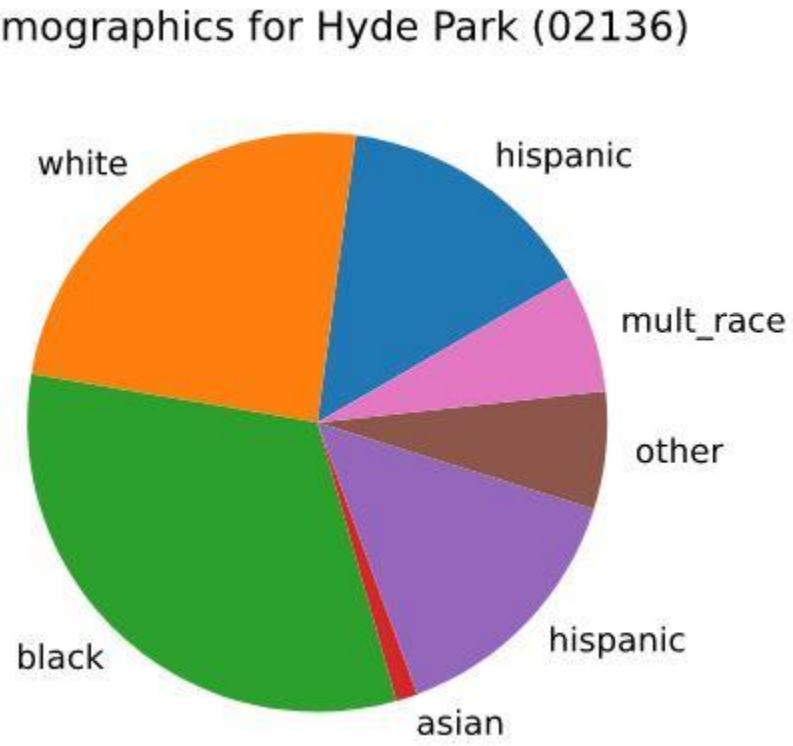


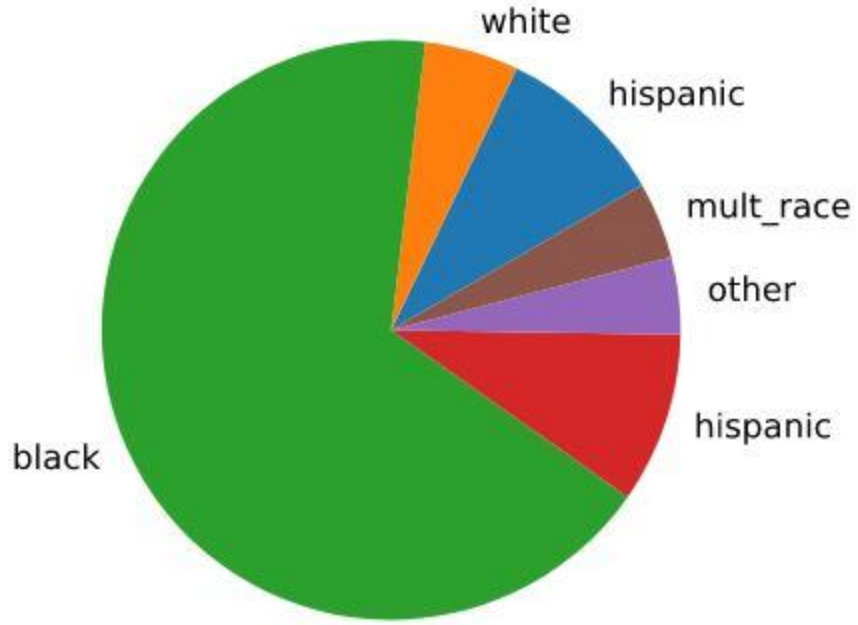
Figure 3: Visualization of Boston as a 15 minute city utilizing our complex spatial analysis. Well resourced parcels, or parcels that are 15 minutes within at least 1 of each type of amenity, is visualized in blue. Under resourced parcels are colored red.

In general, we can see that our results from our simple analysis and complex analysis are consistent, strengthening our confidence in our results. Most of the underserved parcels are in south Boston, which make sense as they are further from the more metropolitan parts of Boston. 78.42% of all residential parcels are 15 minutes within each type of amenity. Major places of interest are Mattapan, Hyde Park, and West Roxbury

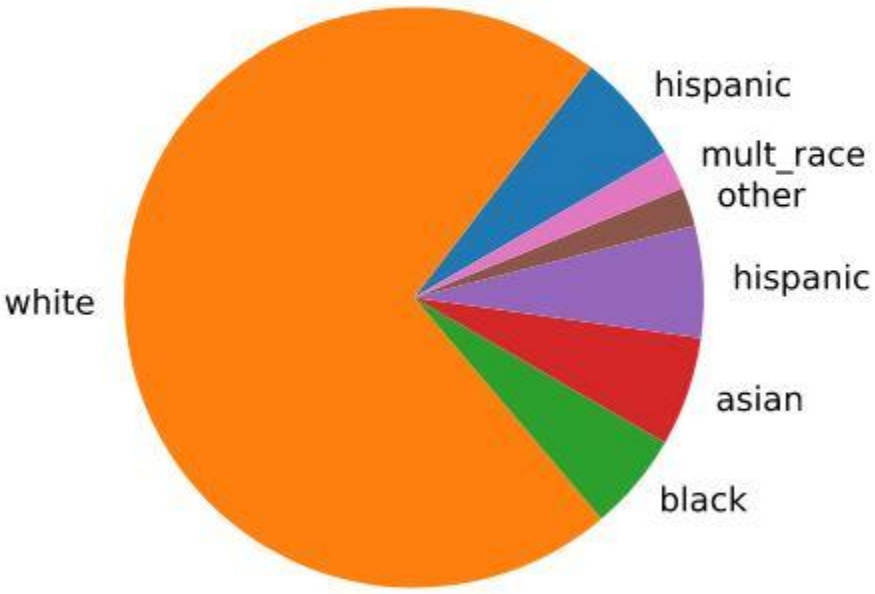
Demographics



Demographics for Mattapan (02126)



Demographics for West Roxbury (02132)



Limitations

We looked at whether at least one of each type of parcel was within each residential amenity. However, a more interesting analysis would be to look at the density/quality of each amenity for a given parcel. For instance, a parcel with only one bodega vs a parcel with 4 high quality supermarkets are treated equally under our algorithm even though the first parcel is more underserved than the second. As a quick aside, we expect the computational complexity of such a problem to be immense. Our current complex analysis takes a couple of hours to run and we expect this time to exponentially increase when looking at density.

The main limitation of the simple analysis is how we assume that a person can walk in a straight line from their residential to the amenity in question. In reality, people are subject to obstacles such as rivers and streets that prevent the most optimal movement. The simple analysis model was built mostly to help build confidence in our complex analysis.

Our complex spatial analysis, while more nuanced than the simple analysis, is much more computationally heavy. We expect this to be a result of the sheer amount of parcels. For future analysis, we believe that there should be a focus on the quality of parcels rather than the quantity. For instance, there are a much higher amount of commercial parcels than other type of amenity. Commercial amenities are much less interesting as they clearly cover all of Boston, but add unnecessary computational complexity to our programs. Ideally, we could identify and remove amenities that are redundant and/or remove amenities that are not important. Such a task is much easier said than done though and would require a deep dive into all of our datasets.

Discussion of our essential questions

As for question 1, the specifics of classification are discussed in the Methodology section. As for question 2, 78.42% of all parcels are within 15 minutes of each type of amenity. As for question 3 and 4, these questions are answered in the discussion of our simple and complex analysis.