Citadel Datathon

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Summary Report

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Topic Question

Our team set out to address the question of how to minimize time spent searching for parking. In our daily lives, we have all faced the dilemma of driving around in parking lots seemingly endlessly, keeping an eye out for an empty space only to find that they are all taken. This process is extremely inefficient and results in problems that are so commonplace that they begin to seem unavoidable. However, we believe that it is possible to optimize the time it takes to park one's car and therefore increase societal productivity in general. To accomplish this, we utilized the vehicle activity dataset, particularly the data pertaining to parking location coordinates (geohashes) and average time taken to search for parking.

Background

Total time wasted parking is a significant drain on the United State's GDP. According to a 2017 analysis done by the research firm INRIX, the search for parking wastes $73 billion a year. In more concrete terms, the everyday American spends "an average of 17 hours per year searching for parking, resulting in a cost of $345 per driver in wasted time, fuel and emissions," and over 40% of motorists have avoided going certain places due to the parking costs. But in addition to these monetary costs, the time wasted parking is also a drain on the environment. Since environmental impact is both a serious consideration today and for any "smart city" of the future, it is imperative to examine the time wasted parking in a more granular manner.

Executive Summary

In our analysis we find that analyzing parking information based on total minutes spent looking for parking, rather than average minutes, is a more illuminating method of visualizing the traffic congestion and parking problems in metropolitan areas. Specifically, it allows us to determine where the greatest parking problems lie, and suggests locations where future parking garages must be built, or other improvements should be made.

It is clear that the targeted improvement of parking facilities in urban environments will save citizen time and money and help cities reach their environmental goals. Between the six metropolitan areas examined, on a yearly basis, people attempting to find parking waste $1.2 billion and generate 23.3 billion pounds of carbon dioxide. While it is not realistic to completely eliminate parking spot finding time, even a small improvement could save Americans billions of dollars and significantly reduce carbon emissions.

Technical Report

We first considered the **average_park_time** data in order to understand the differences in parking issues between some of the major metropolitan areas of North America: Atlanta, Denver, Durham, Houston, Los Angeles, Santa Ana, and Toronto. Through Google Maps' API, we took the **average_latitude_park** and **average_longitude_park** coordinates and plotted the corresponding park times. The color scale was normalized such that green locations denote low wait-time parking areas and red locations denote high wait-times. As expected, the highest wait-time areas are mostly concentrated in urban, developed areas. Figures 1 through 7 (shown below) depict the wait-time concentrations of these metropolitan areas.

Figure 1: Toronto, Ontario, CN

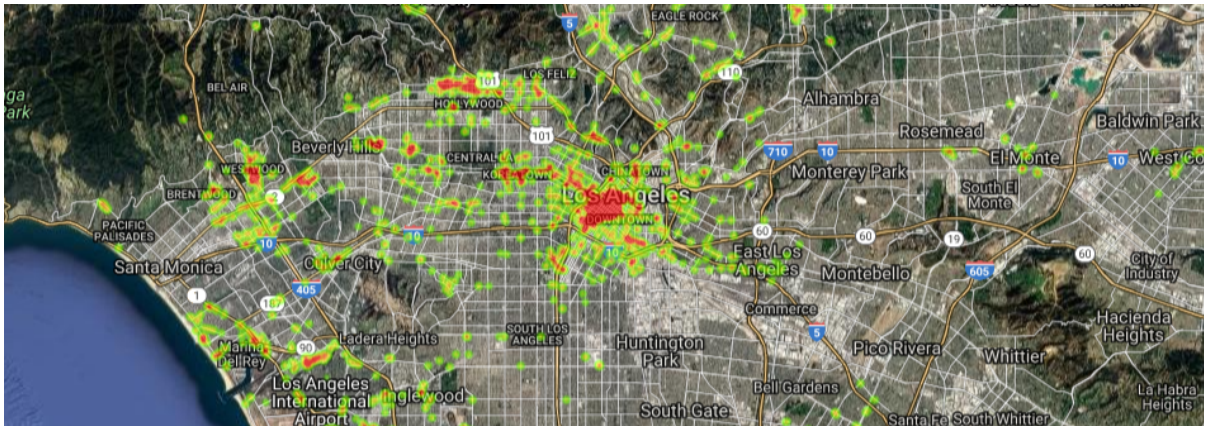

Figure 2: Los Angeles, California

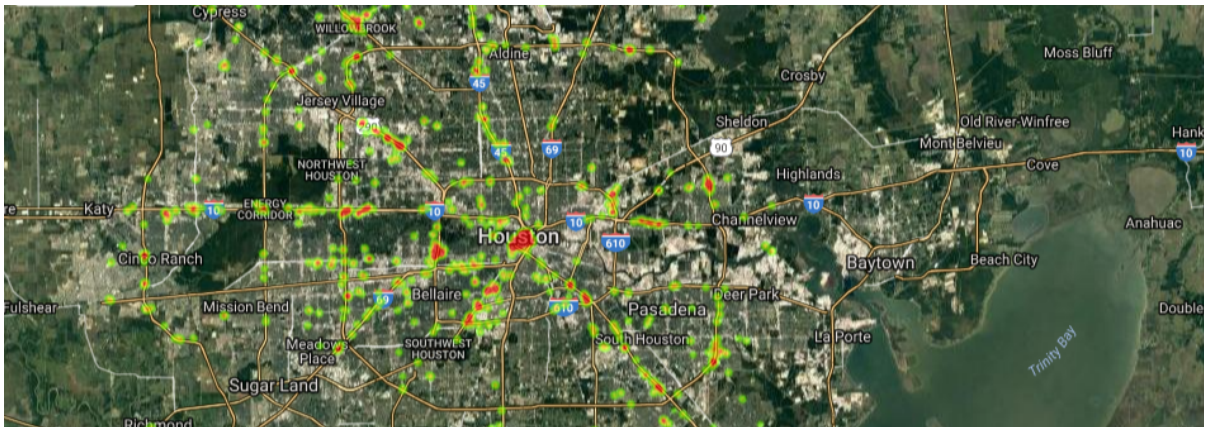

Figure 3: Houston, Texas

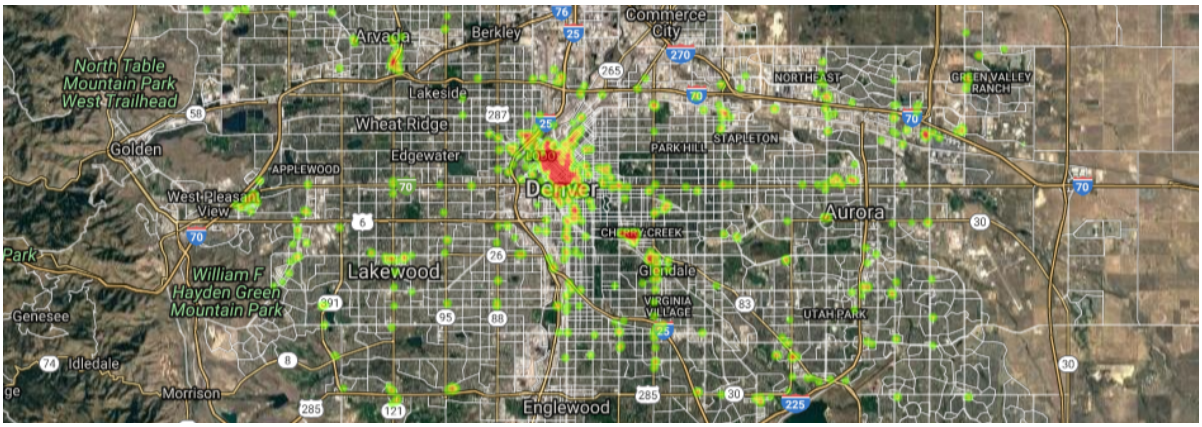

Figure 4: Denver, Colorado

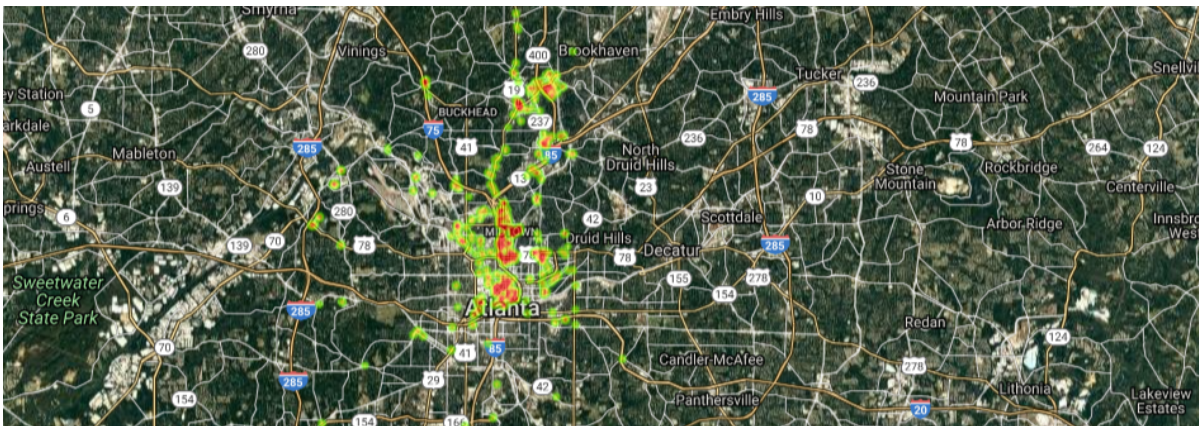

Figure 5: Atlanta, Georgia

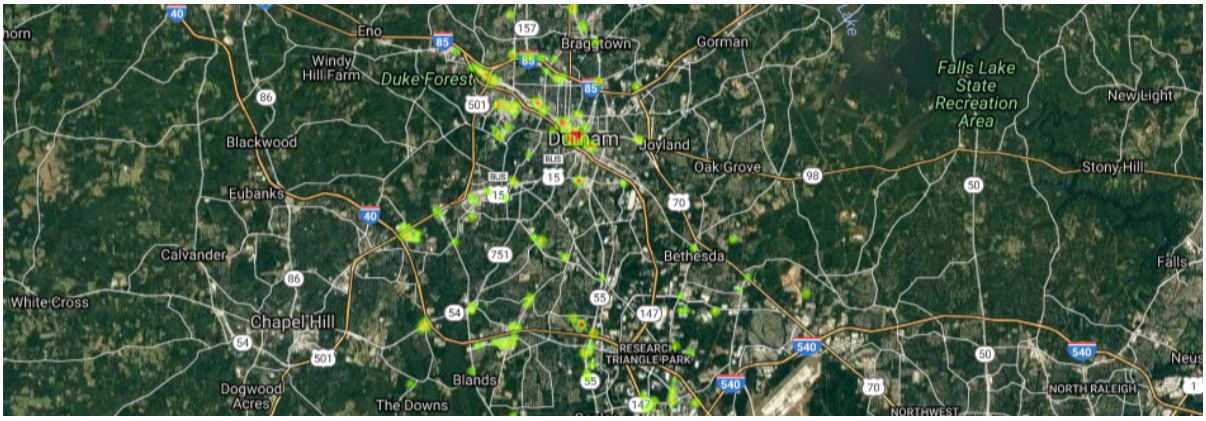

Figure 6: Durham, North Carolina

We also conducted analysis on **total minutes of time wasted circulating for parking**, in addition to the **average_park_time** given in the vehicle_activity data table for the following reasons:

1. Average park time is only measured in areas where there is parking, where in reality someone unfamiliar with the area may search for parking in places which do not have spaces.
2. Average park time does not reveal the total number of minutes wasted searching for parking in an area--an urban area where thousands of minutes may have been wasted parking appears the same as a rural area in which only a few minutes may have been wasted parking.

Therefore, by converting **geohash** locations (153 meters by 153 meters) to latitude longitude coordinates, getting the percent time wasted circulating for parking from the JSON string in **circling_distribution**, converting that to real minutes wasted circulating (by multiplying it by the **total_searching** column), and then summing up time wasted by geohash locations, we created the heat maps (Figures 7 through 12 below), which indicated total time wasted in each metropolitan area. The *top map* is the new heat map, and the *bottom* is the old heat map.

Figure 7: Toronto, Ontario, CN

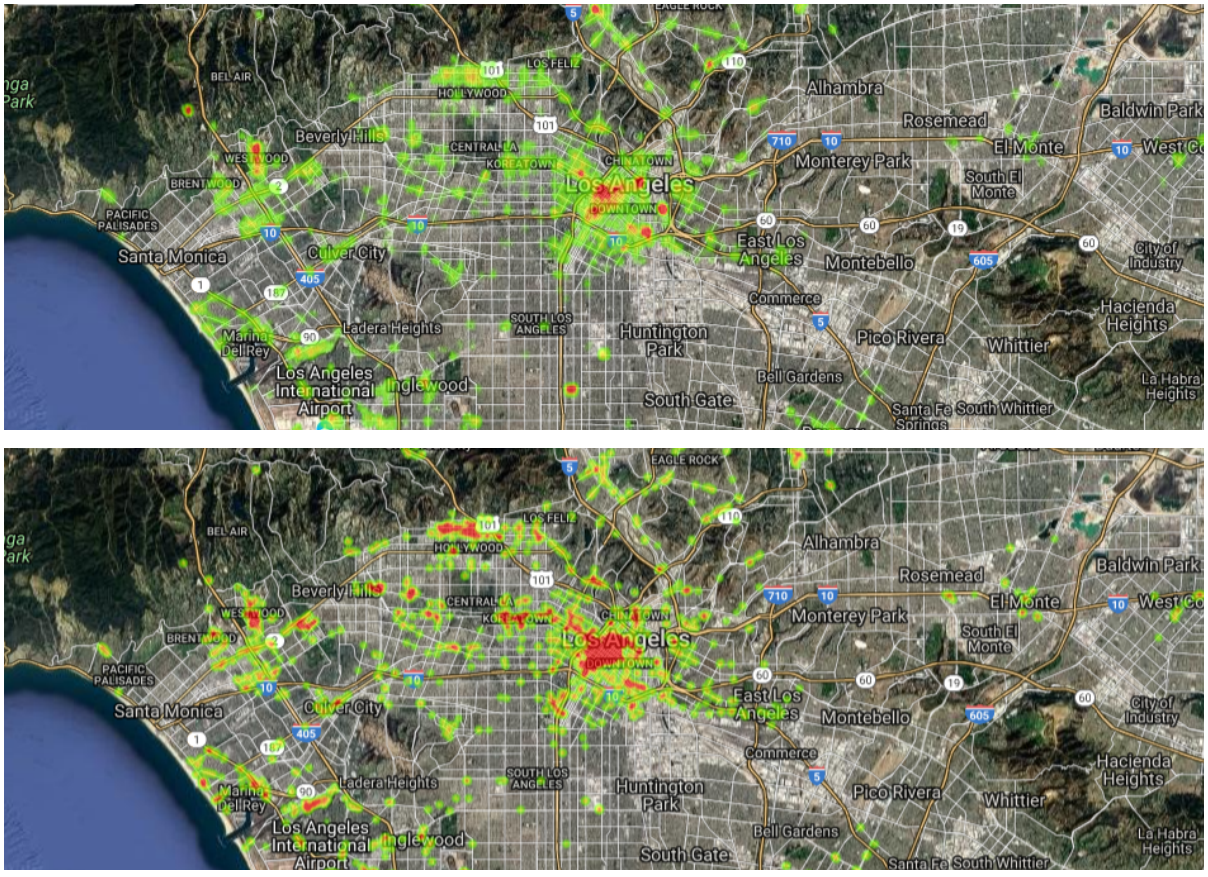

Figure 8: Los Angeles, California

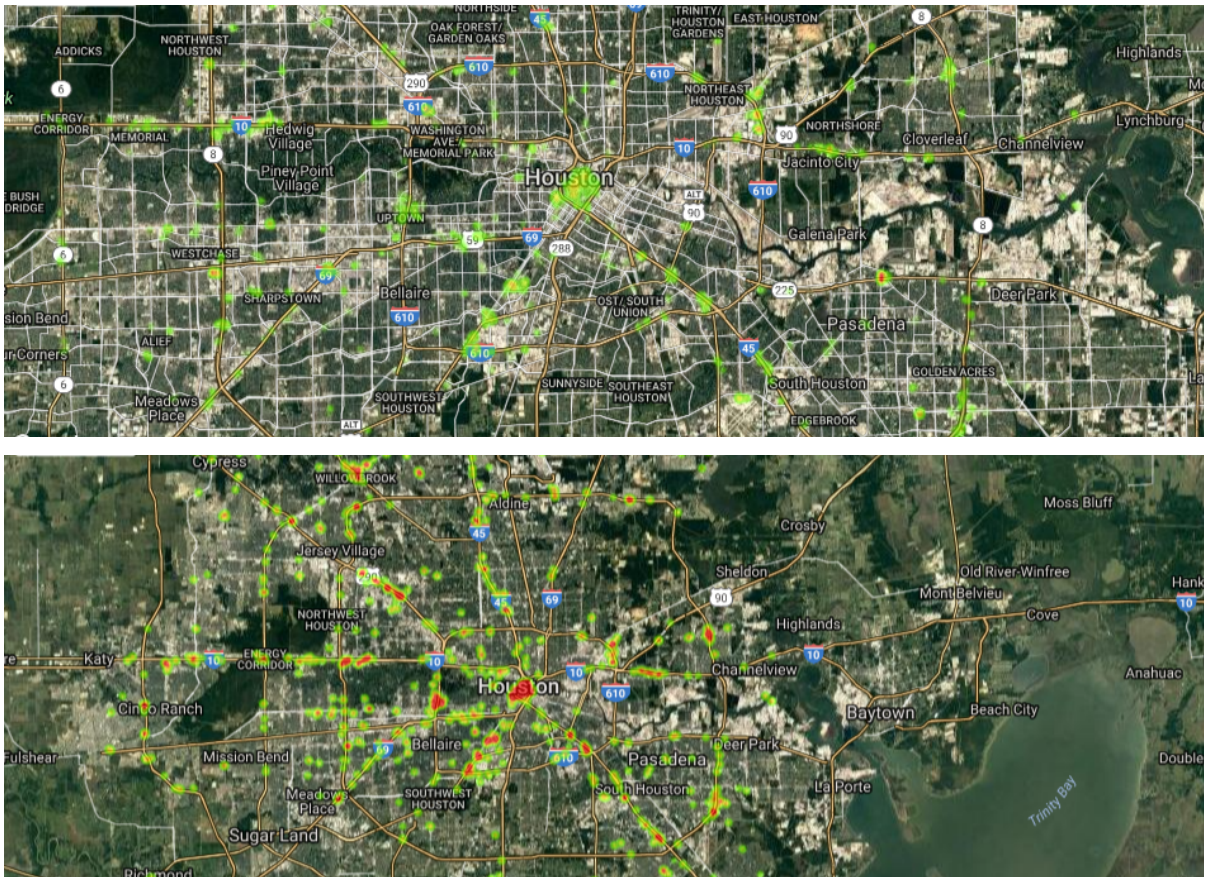

Figure 9: Houston, Texas

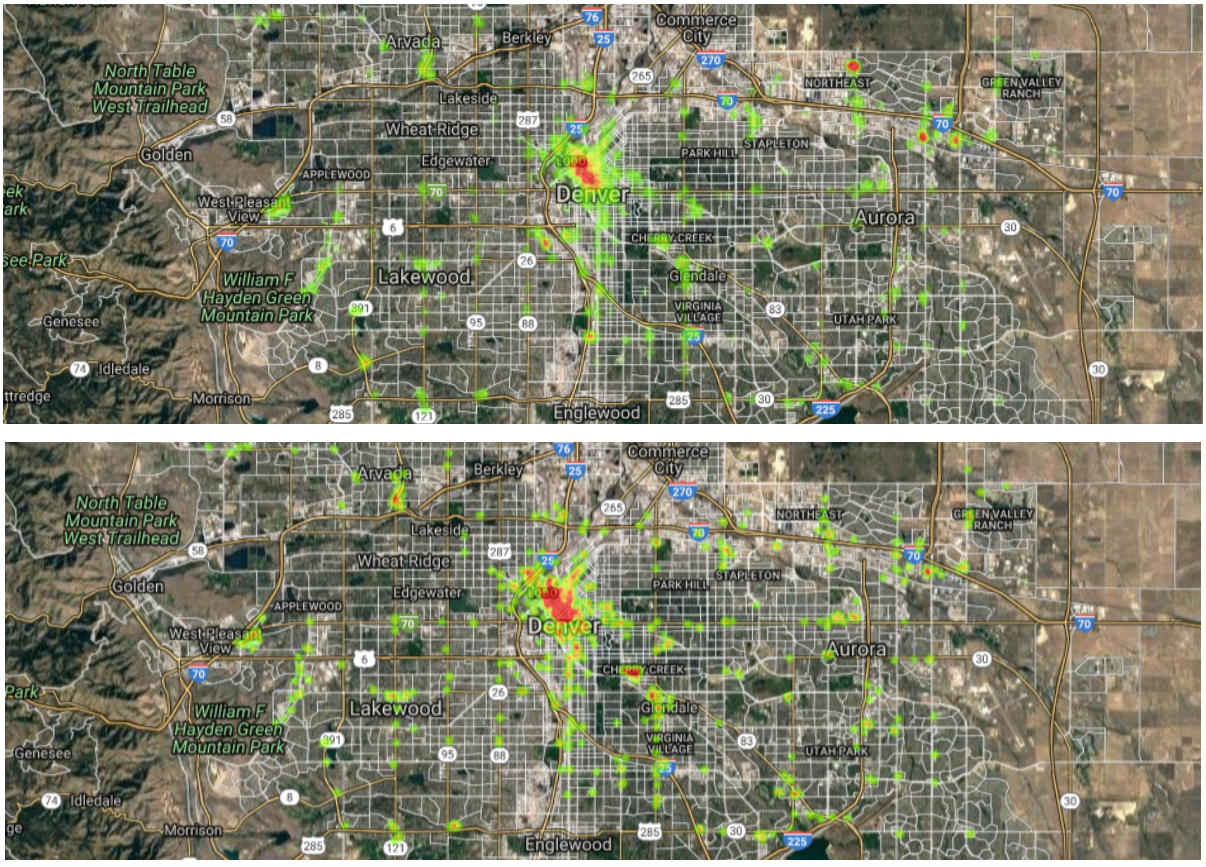

Figure 10: Denver, Colorado

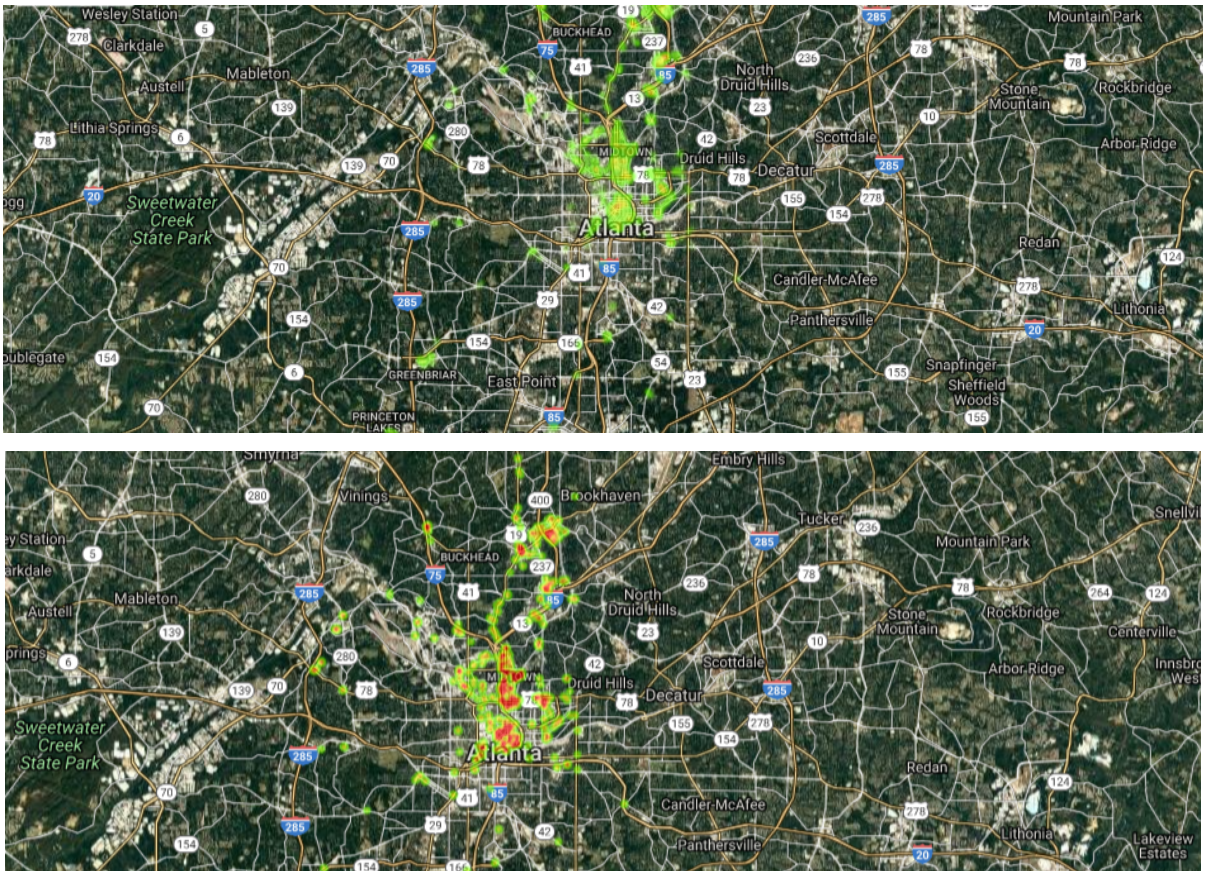

Figure 11: Atlanta, Georgia

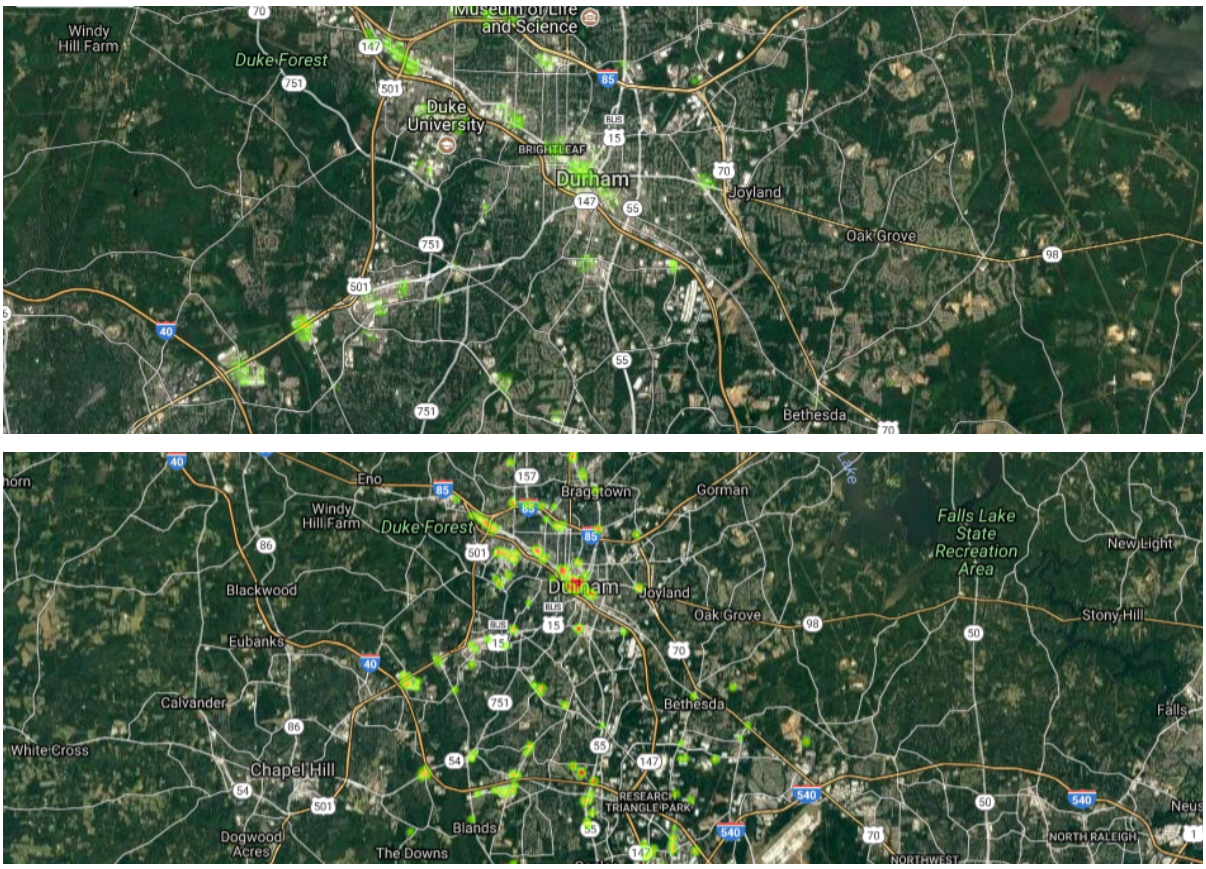

Figure 12: Durham, North Carolina

When looking at these maps side by side, it is clear that an analysis performed based on total minutes spent parking clarifies exactly where major parking problems exist. An analysis based only on average minutes parking makes it seem as though huge chunks of downtown metropolitan areas are problematic when it comes to time wasted parking. Examining total minutes wasted parking reveals the major problem spots of each city, and suggests locations where additional parking garages could be built, or other parking solutions could be implemented.

We examine two consequences of long parking times: money spent on gasoline and carbon dioxide emissions. To calculate these values we required several values from outside data sources. First, according to the U.S. Bureau of Labor Statistics, the average price of one gallon of gas in an urban environment in 2017 was $2.49. Furthermore, the Environmental Protection Agency estimated that in 2017, the average car has a fuel efficiency of 25.8 miles per gallon. Finally, we assume that a car looking for parking navigates at the typical urban speed limit of 25 miles per hour. Using these three values, we estimate money spent on gasoline from the minutes spent looking for parking in an area. In addition to money spent, burning gasoline creates carbon emissions. To approximate carbon dioxide produced, we use the U.S. Energy Information Administration's estimate of 19.6 pounds of carbon dioxide produced per gallon of gasoline burned.

The total cost of searching for parking in each metropolitan area as measured through time spent, money spent, and carbon emissions produced can be found in Table 1.

Table 1: Yearly Costs Incurred While Looking for Parking in Each Metropolitan Area as Measured Through Time Spent, Dollars Spent, and Carbon Dioxide Emissions generated

Metropolitan area	**Time spent (days)**	**Money spent on gasoline (dollars)**	**Carbon dioxide emissions generated (lbs)**
Toronto-York-Peel-Halton, ON	**224.2**	**$573 million**	**11.2 billion**
Los Angeles-Long Beach-Anaheim, CA	**153.9**	**$393 million**	**7.7 billion**
Houston-The Woodlands-Sugar Land, TX	**35.3**	**$90 million**	**1.8 billion**
Denver-Aurora-Lakewood, CO	**31.2**	**$80 million**	**1.6 billion**
Atlanta-Sandy Springs-Roswell, GA	**14.6**	**$37 million**	**0.7 billion**
Durham-Chapel Hill, NC	**6.7**	**$17 million**	**0.3 billion**

Each year, hundreds of person-days are wasted looking for parking in addition to billions of dollars spent and pounds of carbon dioxide generated. A reduction in time spent searching for locations to park could save time, money, and the environment.

While there are several possible methods for reducing the time people spend searching for parking, one of the most promising is automation. For example, in recent years, parking garages which identify how many open spots are in each row have become increasingly common. A similar system for street parking would allow drivers to identify spots from further away. Even more promising is the possibility of tracking open parking spaces and overlaying the

data on GPS programs in phones and cars. This would replace “searching for a spot” with “driving to a spot that is known to be open”, which would be much more efficient. Our analysis suggests that such advancements in automation, made possible by the Internet of Things (IOT) and developing technology, could have a significant positive impact on all drivers and the environment.

In our future endeavours we believe we would be able to expand upon these ideas greatly. Since we have so much data on individual parking regions, we should be able to predict optimal locations where one should park their car. By taking into account how much time it takes to park in an area and the extra time it takes to walk the extra distance (since quick parking can be farther away from one’s final destination), we can predict the best location to park for a given destination.

References

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http://inrix.com/press-releases/parking-pain-us/

https://data.bls.gov/cgi-bin/surveymost