Study of the Micro-Mobility Services in Today's Generation

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ABSTRACT

Micro mobility services are increasingly being adapted as an alternative transport mode in the urban environments, especially for short trips as it has the potential in connecting people better with the public transit, reducing too much dependency on the private cars, and making the most of existing space by rearranging the vehicle. It is an eco-friendly, cost-effective solution to the increasing traffic traffic in the urban areas. These exclusive features of micro-mobility services have drawn our attention to conduct a study in this area by collecting data of the active services in different cities in the world, analyzing the impact of these services and thus presenting the answers to research questions regarding availability of the bikes, number of trips and about the user preferences. Our main goals are to provide suggestions to the companies which are operating these bikes as well as to the consumers who are using these bikes.

1. INTRODUCTION

Transportation is one of the most basic needs of human beings and over that these micro-mobility services are gaining huge popularity in today's world. Air pollution, greenhouse gas emissions, traffic congestion or unavailability of parking spaces are some of the drawbacks of traditional forms of mobility. To tackle these problems, micro-mobility services come into play. They are helpful in moving people over relatively shorter distances [1]. These services come with a set of small vehicles such as electric scooters, docked or dockless shared bikes, electric skateboards and electric pedal-assisted bikes. Dockless bike-share is that sharing facility of a bike in which no station is allocated to that bike. They are available in pedal and electronic modes. Station-based bike share is that sharing facility in which the stations are allotted to a bike for picking up and returning the bikes. This type is also available in pedal and electronic mediums. Lastly, is the scooter share system which is a motorcycle with a step-through frame and a platform for the rider's feet. It is available in two types, foot-based and electronic. All electronic-based vehicles have engines installed in them for the locomotion [2]. They provide a fun, quick, economical, and environment-friendly way to get around the town. They also beat the long-distance walking. It is quite helpful for those who don't have vehicles to land using these services, they can easily travel to the places they want. The overwhelming adoption of these services offer a unique opportunity through which we can draw a comparison between different cities.

E-scooter sharing systems were introduced in 2017 in the US and now they are the fastest emerging micro-mobility services. The most famous companies which are providing the e-scooter services are Bird and Lime. Bird hit 10 million scooter rides within 12 months of first appearing on Southern California streets and sidewalks, while Lime users took 34 million trips across the company's platform of vehicles including e-scooters, electric and pedal-assist bikes in that company's first year [1]. These are the fastest US companies to reach billion-dollar valuations. In 2018, people took 84 million trips on shared micro-mobility in the United States, more than double the number of trips taken in 2017. Also, people took 36.5 million trips on station based bike sharing systems and 38.5 million trips on shared e-scooters [3].

The user just has to follow a few steps. First, the user has to download an app on his/her smartphone for a scooter company like Bird, Lime, Jump etc and create an account by adding credit card information. When the user opens the application, he/she will be provided with the list of other nearby scooters or bikes by the map. According to the map's location and information, the user can go to that specific location of a nearby scooter and then should scan a barcode to unlock the scooter. Then, the user is set to go for a ride. There are few instructions to be followed like wearing a safety gear, how to speed up or down, how to follow the traffic rules etc. Later, he/she can park the scooter anywhere and end the ride on the app. A 2-mile ride takes about 10 minutes and costs less than $3. The uber ride may cost more than $15 but we can start any electric scooter for $1 and then 15 cents a minute thereafter. Also, there is no additional mileage fee, no surge pricing or prime time. The price we pay is the same no matter the distance we cover. Time is the only variable that will affect the total scooter-sharing bill [4].

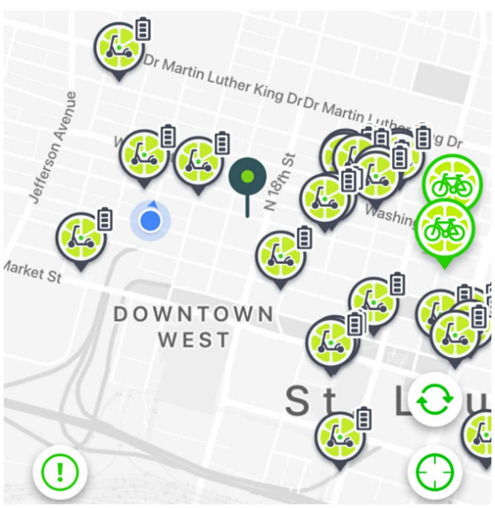


Figure 1: Lime Scooter Application Screenshot

Bird has put over 1,000 of its scooters on the streets throughout eighteen U.S. cities, including Los Angeles, Dallas, and Washington, D.C. It has already been taken for over 1 million rides since launching in September 2017. Bird has raised $275 million in fresh funding at a $2.5 billion valuation, bringing its total financing to about $700 million [5]. Similarly, Lime was also launched in 2017 and has raised $467 million and is valued at $1.1 billion [6].

The purpose of this paper is to identify a number of ways in which these new mobility services can serve to improve or increase the already existing city's approaches. We would like to help the cities achieve their sustainability goals, and their further investment in the safe infrastructure. Another purpose is to highlight the data collected that we have collected and we want to propose a new set of measures for assessing similarity based on the mobility patterns exhibited by the users of these e-scooters bikes.

2. RELATED WORK

There is an interesting literature available on bike sharing systems. Micro mobility constitutes forms of transport that can occupy space alongside bicycles [1]. Our approach for collecting data has been inspired from *"Peeking Beneath the Hood of Uber"[7]*. The way they calculated the measurement points of uber cars and taxis, our way of calculating our measurement points is also the same. Before analysis, our data was also cleaned to remove the outliers. Another inspiration for working on this paper has been drawn from *"Mobility Modeling and Prediction in Bike-Sharing Systems"[8],* who have worked to propose bike rebalancing algorithm design. The major issue is the uneven distribution of the bikes around the city. We can see people just throw the bikes anywhere and sometimes it is not even in a good position. So, the authors proposed a mechanism to model and forecast the users' check out behaviours. Hence, the mobility modeling and prediction algorithms provided insights into the operations of bike-sharing systems, and have been proved useful for the prediction of bike availability at each station, laying a foundation for further efficient rebalancing design in bike-sharing systems. The very interesting paper to read on was *"Towards Precise Localization of E-Scooters Using Sidewalk Ramps"[9],* where they presented a solution to the problem of GPS error i.e. a scootloc, which enables precise e-scooter localization by leveraging physical characteristics of the sidewalk ramps to correct the GPS error. One of the articles *"Usability of eScooters in Urban Environments - A Pilot Study"[10]* also researched in this area and suggested e-scooters can help to reshape the face of modern cities without the exhaust fumes and noisy appearance of a two stroke engine. Also with the low energy consumption, less parking space requirements and less noise, these vehicles can overcome congested, exhausted riddled streets and overcrowded parking spaces by substituting cars. Another inspiration has been drawn from the *"Shared micro-mobility patterns as measures of city similarity"[11]* where they identified a number of ways in which these new mobility services can serve to augment the existing city similarity approaches. Our method of extracting trips is similar to the approach explained in this paper. However, to our knowledge there is not any paper published on the dockless scooters. These are the studies conducted on the shared bike systems and there has been no such measurement study done for the e-scooters yet. We are motivated to work towards it and would like to provide useful information about the optimized redistribution of dockless scooters, optimized recharging time and spatial temporal dynamic booking time.

3. METHODOLOGY

The goal of our project is to provide recommendations or suggestions to the service providers and to the customers regarding the above stated concerns in the related work section based on the spatiotemporal availability patterns for the nearby scooters of different companies in different areas. There are many service providers as we can see a variety of bikes of different companies like lime, Jump, Bird etc. Our recommendation can help the e-scooter companies to achieve better utilization rates. We see that there is an uneven distribution of the bikes due to the randomly changing supply and demand. People throw the bikes or just park it at a very arbitrary place like it is thrown sometime under a tree. We will also explain the peak hours of the day regarding supply and utilization of e-scooters.

In this section, we will discuss our approach for collecting data of the scooters available in different neighborhoods of the cities as mentioned in table 1. We have periodically fetched information regarding the nearby available scooters throughout the city (except for lime bikes because it returned a maximum of fifty bikes around any source geolocation. Due to the limited number of lime accounts, we were not able to trace all the available bikes of lime in a city) that included the ID, the expected mileage, the battery percentages as well as the latitude-longitude of each scooter from the actual companies' servers. Other than the lime, we did not face any data limitation issues in any of the other services. Then this data will be cleaned and processed through the python scripts that were developed to extract the useful information about the bike's trip statistics through various algorithms and built-in libraries.

City	**Services**
Brussels (Belgium)	Circ, Jump, Lime, Tier
Chicago (US)	Jump, Lyft Scooter
Washington DC (US)	Bird, Jump, Lime, Lyft, Skip, Spin
Detroit (US)	Bird, Lime, Spin
SanFrancisco (US)	Jump, Scoot
Lisbon (Portugal)	Bird, Circ, Jump, Tier, Voi, Wind
Madrid (Spain)	Bird, Circ, Jump, Lime, Tier, Wind
MexicoCity (Mexico)	Lime, Movo
Paris (France)	Bird, Jump, Lime, Tier, Wind
TelAviv (Israel)	Bird, Lime, Wind
Zurich (Switzerland)	Bird, Tier

Table 1: City and the services available within the city.

3.1 LOCATION SELECTION

In this study, we focused on the dynamics of e-scooters in advanced cities mentioned in the above table. Paris is one of the world's topmost tourism cities. It has embraced the electric scooter, giving visitors and residents a breezy alternative to the metro [12]. Similarly, DC, Denver, Zurich, and San Francisco are home to the successful bike-sharing programs. These all cities have provided another option to the visitors for visiting malls, museums, around the city, downtown etc using these micro-mobility services.

3.2 DATA COLLECTION

In this section, we present the process of gathering data of dockless bikes in the eleven cities. The data was collected from 6th June to 29th November, 2019. To overcome the shortcoming of the unavailability of public APIs of under observation application, We have collected the data using the web requests of passenger applications of the above mentioned different services such as lime, bird, jump etc.

After the user authenticates with any particular e-scooter service's application, the app sends a *'pingrequest'* network message to it's server every minute for each experiment source geolocations. Each *'pingrequest'* includes the source geolocation i.e. latitude and longitude. The server then responded back with a message of JSON encoded list of information about all the available scooter types which are in and around the user's place. Each scooter is represented by its unique scooter ID, battery life, expected mileage, and geographic coordinates. So, for gathering this data, we created a script that logged into each scooter's application and which sent *'pingrequest'* messages every minute, and hence the responses were recorded. Thus, we can control the latitude and longitude's coordinates sent by the script and can collect data from any arbitrary location. We collected information for the large areas by blanketing them with the measurement points.

3.3 DATA VARIABLES

Substations: Substations are the kind of dynamic stations where the people park scooters or bikes according to their own convenience or according to their own destination location. Since these are the dockless bikes, these can be parked anywhere and they don't have any fixed stations. We have divided the city into multiple substations for the sake of comparison and each of them are considered to be static throughout our experiment of size 3*3 miles geometric square region. We ran a script which calculated the nearby places of each custom defined substation where we can find the bikes. For the geo coordinates of each substation, we got the nearby places using 'heremap' and 'google maps'. Each station is associated with the neighbouring places. We have defined the categories of places which are most likely to be visited like the downtown, shopping malls, museums, restaurants, pubs, bars etc. There are neighbouring stations too and they have inter as well as intra trips.

Neighbouring Types	**Description**
Urban Core (downtown)	Place where there is diverse mix of young single professionals, low to middle income families and seniors get together
Ethnic	Place where Immigrants from a particular ethnicity, young couples, budget-conscious singles get together
Active/Resort	Place where affluent and active middle-aged adults and seniors get together
Golf	Place where families with young children, retirees, golf fanatics get together
New Urban	Place where educated, affluent-to-middle income couples with no or few children, young single professionals get together
Historic	Place where style-conscious middle-aged couples, aging adults who grew up in the neighborhood, home-improvement buffs get together
Urban Pioneer	Place where diverse mix of young singles and couples, recently divorced and single parents, aging retirees who have lived in the neighborhood for years, immigrants get together

Table 2: Description about the neighbourhood area

Supply: Using the data returned in *'pingrequest'*, we calculated aggregate supply and demand within our measurement region. Supply refers to the number of scooters observed within a particular substation throughout the day or time slots. We know that all substation's supply is equal to the total city's supply. Supply is the number of available scooters per mile at any given time at any particular neighborhood.

Utilization: Utilization (or demand) measures how many scooters are going on a trip. There are two issues in this: First, the company is not giving us the utilization data, so we have to infer all the information from our own collected data. Secondly, we have not considered short distance in our utilization because of the inaccuracies and noise in GPS locations of the scooters. Secondly, after a battery recharge, they get redistributed and hence we don't count it as a trip. Trip means a bike is going offline and then reappears at a different location with a positive difference in battery percentage before and after the recurrence. The sample rate means that at what frequency the data is being collected. Battery percentage, Mileage covered, Latitude and Longitude are important data variables as these will help us in answering some of the raised research questions.

4. DATA PROCESSING

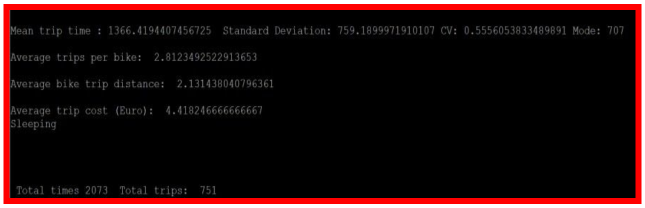
We have used comma separated values (CSVs) to store the data that was collected periodically and a python platform to build our own processing scripts. The script 'dataset.py' reads the CSV for each day in order and processes the data from it. The data was stored using the dictionaries that had bike IDs, battery level, location_latitide, location_longitude etc. Initially, 'geopy' and later a native implementation of a geolocation function was used to find the length of scooter trips. Each trip was cross referenced for mileage as well as for battery usage and the results were displayed on the console. The statistics library was used to find meaningful values for the raw data collected from the CSVs.

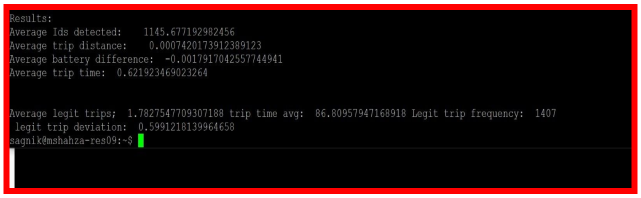
5. CONTRIBUTIONS

- I started this project by reading some related papers about micro-mobility services.
- The initial task was to generate the city sub-coordinates using a 'dividecity.py'. These sub-coordinates were then mapped in leaflet map 'citycoordinates.html'. After running this script, different files were formed having all the dynamic sub-station's coordinates in the folder 'CityCoords'.
- These coordinates were copied into a script 'closestStation.py' which used mapping scripts and geolocation libraries to calculate the bike positions relative to different locations (stations) around the city.
- Next, I found the nearby places using 'gmap.py' and 'hereplaces.py'. These files were generated in the folders 'CitiesPlaces' and 'herePlaces'.
- Then, I also started a write up for this research study and covered major portions starting from introduction, methodology, data collection etc.
- Worked with Hassan Ali Khan and Sagnik to create a separate script for the necessary exclusions and cleansing of the data points to extract reasonable stats for the bikes. I have regularly attended all the meetings.

6. RESULTS

We have collected the data of scooters from different neighborhoods of the cities mentioned in the table above. We have periodically fetched the information for the nearby available scooters, bikes which include the scooter's ID, expected mileage, battery percentage and latitude/longitude from the actual scooter companies' servers.
The two cities studied in the scope of this paper are Paris and Washington DC. We derived statistics for the eleven cities using our scripts.. We found that the Jump bikes in Paris had an average trip time of 1366 seconds with a deviation of 760 seconds. The average trips made by each bike were 2.8 a day and the distance was 2.13 km. The trip cost for Jump in Paris was 4.41 euros. This was in alignment with the service provider's actual price on their website. Bird in Washington DC made an average of 1.78 trips a day for a bike with a trip time of 86 seconds. The deviation was 0.6 with a trip frequency of 1407 for the day.





6.1 EXPECTED RESULTS:

We are still working on this part and after further cleaning of the data, we will be moving on to find the results for some of the important research questions like whether e-scooters are a better alternative compared to the existing ridesharing services like uber, lyft etc, which factors can cause the low utilization of the e-scooters, what is the better scooters' recharge time for e-scooter companies, Do we observe less utilization for the scooters with low battery left? If yes, do the other companies perform well at that time.

We know that the e-scooter company vans redistribute the bikes every day. But, we will provide answers to how effective the distribution is and how it evolves during the day, what could be the more effective time and pattern of the distribution, what kind of neighborhood can maximize the utilization of e-scooters (education level, mean age, popular race in the neighborhood), What is the average trip length and average trip time on e-scooters, what is the supply and demand of e-scooters present per mile of a particular neighborhood, how much will you have to walk to get an e-scooter (effect of the walking distance on the booking of scooters at different times of the day and different parts of the week), In how much time (on average) a scooter goes offline, what is the maximum utilization time and geolocations, what are the availability hours (as companies have to charge the e-scooters and redistribute them, how many trips are observed in our experiment by each company and how much do they earn(estimate of earnings using their pricing models).

These are some of the research questions that we really wish to answer by conducting our research study. We hope to complete this soon and should be able to present a paper on this hot topic.

7. LIMITATIONS

There were few challenges that we faced while collecting the information. Firstly, there is no paper on the dockless bikes. Secondly, we could not get the public APIs. We were not able to get data of the whole city where lime is used as explained above because the lime company returned only upto fifty bikes and the *'pingrequest'* network messages could only make five requests per minute. We could only make limited lime accounts because it needed a real API so that it could send an OTP to our devices. We had an upper threshold i.e. limited requests per minute. The main challenge for the data collection was from Bird and Lime whose IDs were not consistent with the standard data collected via the API calls. The problem was that Bird IDs would either be regenerated or would reappear i.e. getting offline and then coming online so many times in a short span of time that it would corrupt the statistics of the paper. It had a time difference of five seven minutes. So, the issue was having different IDs but the same bikes whereas the lime has an issue of different bikes but the same ID. Also, the bird scooter had a unique issue where there was a lot of noise in the data. So, we read all the CSV data and then excluded outlying datas like negative trip distances, positive battery percent changes (except for 100% since that denotes their charging times). In this way, this data was then further cleaned by performing the cross verification of the trip times and distances with the known bike mileage to have reasonable statistics for Bird.

8. ACKNOWLEDGEMENT

I am thankful to Hassan Ali Khan for his constant support, motivation to do this project. I am thankful to him for giving me this opportunity to work on such an interesting research study. I am grateful to Dr. Muhammad Shahzad for letting me do this project. I am also thankful to Sagnik who has a very nice potential to do the research study. The project began as a study of lime scooters and usage mapping followed by moving our focus to the usage statistics

and key results for the specific cities. I am looking forward to completing this project and presenting a very nice, informative paper on this soon.

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