UNIVERSITY of WASHINGTON

# Micromobility in Smart Cities: A Closer Look at Shared Dockless E-Scooters via Big Social Data

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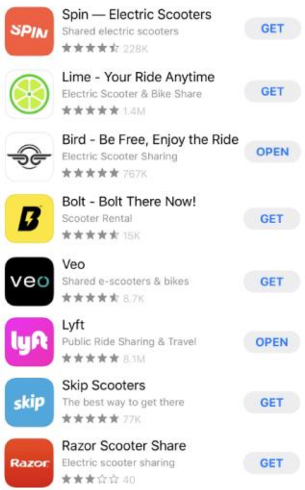
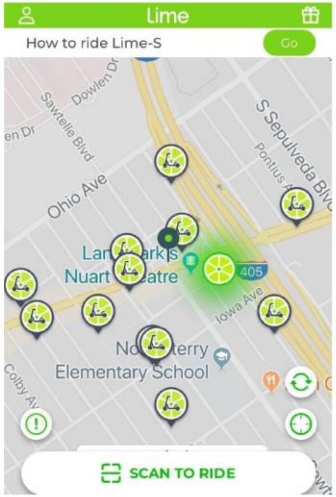
# Background

- **Pros**: affordability, easy accessibility via an app, and zero emissions.
- **Cons**: traffic rules, public safety, and parking regulations.
- **11%** of Paris residents reported using e-scooters either frequently or from time to time [1].
- According to NACTO[2], people took **38.5 million trips** on shared e-scooters in 2018.


(a) E-scooter




(b) E-scooter apps




(c) App UI

# Motivation

- A missing research perspective from the riders’ comments shared via smartphones, especially via social media apps.
- Social media is a good data source to investigate the e-scooter usages.
  - ❑ **Diversity**: multimodal social data (text, image, timestamps, GPS, emoji, etc.) enables detailed profiles of e-scooter sharing services in various aspects.
  - ❑ **Scalability**: performing a large-scale study of micromobility with social media data is flexible and effortless.
  - ❑ **Transparency**: public social media platforms (e.g., Twitter) addressing potential concerns of research non-reproducibility.

# Methodology

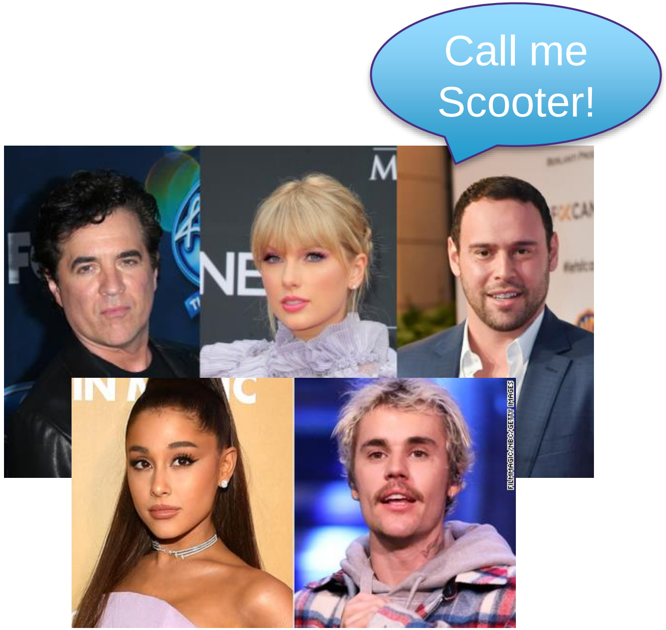
- Use Twitter to collect data
  - ❑ Free APIs to collect tweets of interest
  - ❑ The fourth most active social networking platform
  - ❑ Users expect the data they post on Twitter to be publicly available
- Big data analytics
  - ❑ Spatio-temporal Visualization
  - ❑ Topic discovery - latent Dirichlet allocation (LDA)
  - ❑ Optical character recognition (OCR)
  - ❑ Logo detection and recognition
  - ❑ Sentiment analysis

# Data Collection & Bot Detection

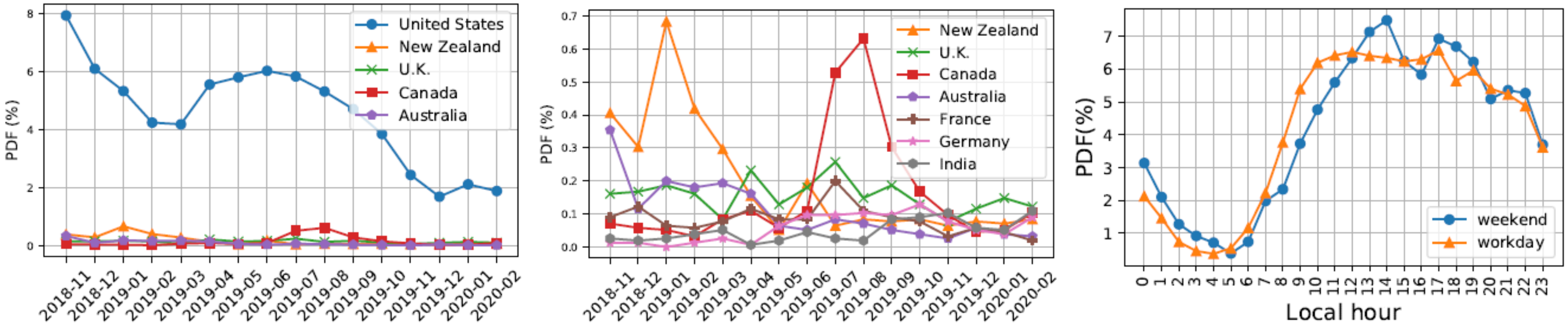
- Twitter's Streaming APIs with keywords of ***scooter*** and emoji 
  - 5.8 million tweets generated by 2.7 million users
  - 178,048 different image URLs (33,851 expired)
  - October 6, 2018 to March 14, 2020
- Remove bots [3]
  - Those who posted more than 525 scooter-tagged tweets, i.e., more than one such tweets per day, during the data collection period
  - Those who posted over 100 scooter-tagged tweets in total and the top three frequent posting intervals covered at least their 90% tweets.

# Data Cleanup

- Word co-occurrence analysis
  - Taylor, Swift, Justin, Bieber, Scott, Samuel, Braun, Ariana, Grande, and Borchetta
  - 1,541,815 related tweets were deleted
- Further reduce false positives
  - Tweets containing the word of ***Share***
  - Tweets containing shared e-scooter brands including ***Bird, Lime, Spin, Bolt, gruv, Lyft, Sherpa, VeoRide, Taxify, Jump, RazorUSA, Scoot Networks***, and ***Skip***.



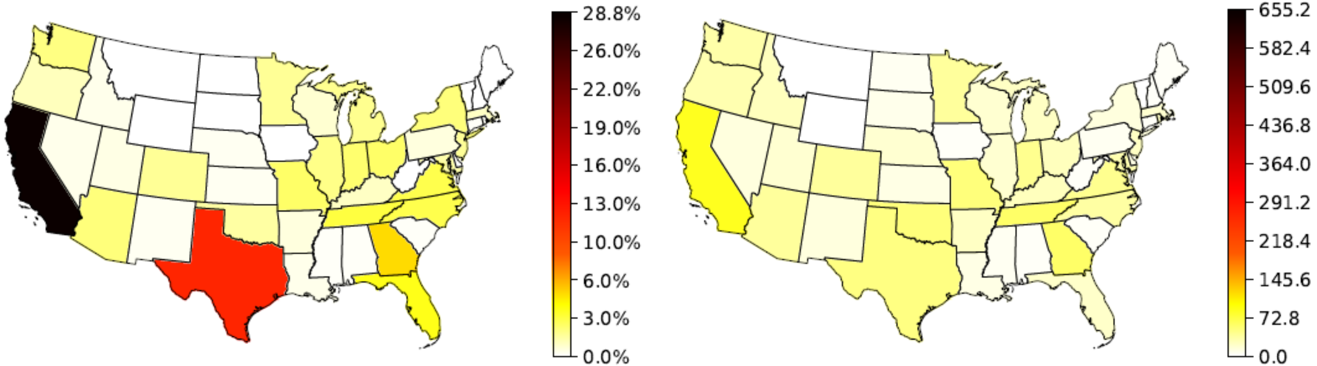
# Temporal Distribution




(a) Monthly dist. by country (b) Monthly dist. w/o the U.S. (c) Hourly dist. in the U.S.

- The United States accounts for more than 82% of all collected tweets.
- Usage peaks in summer and drops in winter.
- New Zealand & Australia ↓, Germany & India ↑, and United Kingdom & France →.
- The most active time during weekdays (weekends) is between 10:00 am to 5:00 pm (12:00 pm and 7:00 pm ).

# Geospatial Distribution




(a) Percentage by state (b) Normalized by population

- California (28.8%) and Texas (11.7%) account for more than 40% of all tweets.
- Six (CA, TX, GA, FL, NC, OH) out of the top ten states with the highest percentages were among the ten most populous states.
- After normalizing by state population, we obtained a relatively smooth distribution.

# Topic Discovery

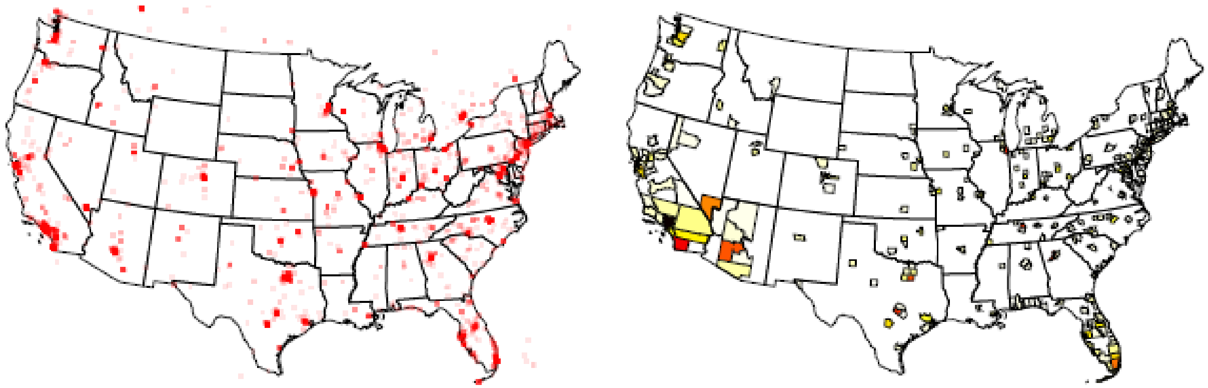
- Data preprocessing
  - ❑ Each tweet content is a single document.
  - ❑ Corrected misspelled words, removed stop words, tokenized words, and lemmatized words.
  - ❑ Performed the term frequency inverse document frequency (TF-IDF).
- Latent Dirichlet Allocation (LDA)
  - ❑ # of topics = 12 achieving the highest coherence score
  - ❑ We clustered the 12 topics into four categories
    - ➢ Deployment
    - ➢ Stakeholder
    - ➢ Operation
    - ➢ Emotion

# Topic Discovery

TABLE I: The extracted topics using the LDA topic model

| | Stakeholder | | | Emotion | | Deployment | | | Operation | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Rank** | **Rider** | **Gig Worker** | **Company** | **Positive** | **Negative** | **Transport.** | **City** | **Regulation** | **Parking** | **Transaction** | **Injury** | **Product** |
| 1 | kid | gig | electr | ride | ride | bike | santa | citi | sidewalk | app | injuri | balanc |
| 2 | kick | worker | startup | around | one | share | monica | program | park | ride | fire | self |
| 3 | adjust | built | compani | fun | got | transport | st | compani | bike | charg | rider | electr |
| 4 | wheel | contractor | san | day | saw | car | loui | pilot | peopl | use | accid | bo |
| 5 | height | gen | market | love | shit | citi | montreal | electr | road | free | recal | skateboard |
| 6 | amp | economi | via | downtown | time | transit | paul | new | lane | unlock | caus | smart |
| 7 | child | lemon | new | san | fuck | trip | toronto | council | use | code | man | board |
| 8 | light | kmh | launch | time | guy | use | joe | bike | block | tri | injur | inch |
| 9 | adult | stabl | ford | rode | hit | mobil | canal | share | ride | one | via | fold |
| 10 | boy | libbi | tech | one | someon | electr | german | come | pedestrian | minut | report | bluetooth |

# Deployment in Cities



(a) Exact $(lat, lon)$ coordinates (b) Geospatial distr. by county

- 3359 exact GPS coordinates located in 579 cities.
- Most extensive scooter deployments occurred in large cities at East Coast and West Coast, and other metropolises.
- Three cities (Los Angeles, San Francisco, San Diego) in California contributed more than 15.6% of all GPS-tagged tweet.

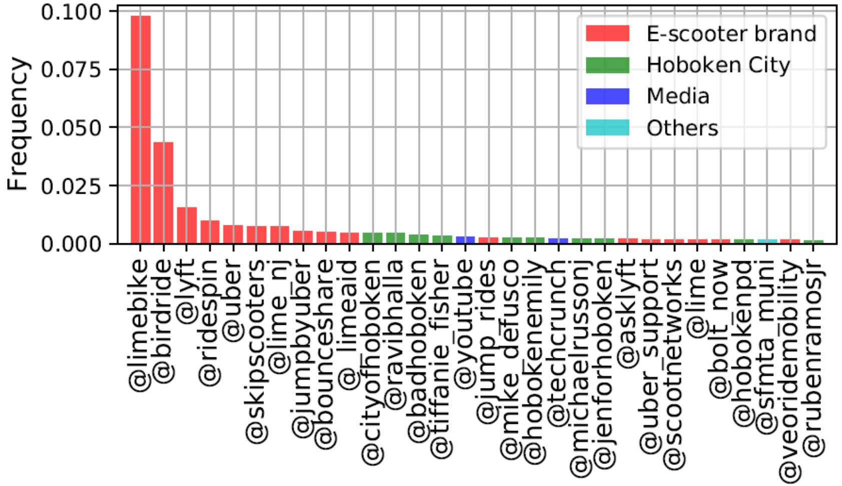
# Policies and Regulations

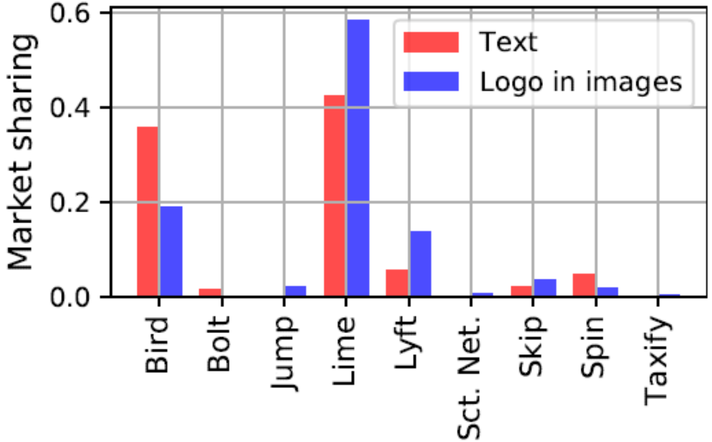
- We surveyed policies on shared e-scooters in ten cities generating the most GPS data.
- Common rules
  - ❑ Self-protection requirements, e.g., wearing helmets
  - ❑ Riding behaviors, e.g., no phone usage while riding
  - ❑ Traffic restrictions, e.g., reasonable max speeds from 15 mph to 30 mph
  - ❑ Parking rules, e.g., not blocking sidewalks

# Rider Profiles

- A great gender gap in shared e-scooters with 34.86% identified as female and 65.14% as male, being consistent with a study [4] by Portland State University, which reported 34% riders identified as a woman, 64% as a man, and 2% as transgender or non-binary.
- Only 4.17% riders were recognized as kids.
- 83.51% users did not wear a helmet when riding, which might be one of the most common risky behaviors.

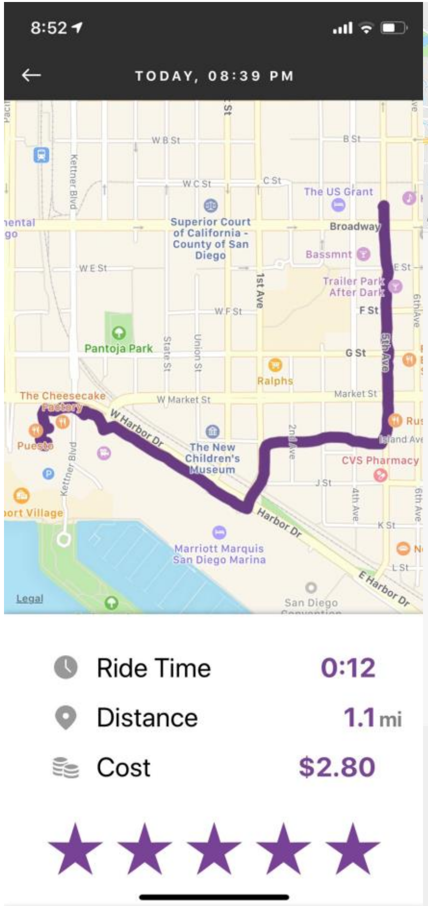
# Scooter Companies

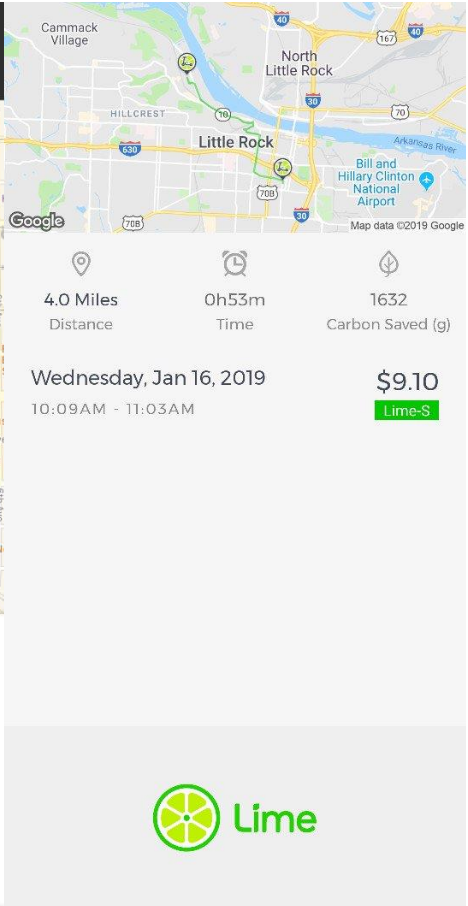



- All the top 10 most frequent mentions are e-scooter brands.
- The top 3 of market shares based on tweet text and recognized logos, i.e., Lime, Bird, and Lyft, agree with the top @mentioned accounts

# Transaction Analysis




- Optical Character Recognition (OCR) to extract the trip information.
- Regular expressions to extract the payment and trip duration.
- Median payment and median duration were \$3.8 and 15.0 minutes.
- Average payment and duration were \$8.9 and 44.3 minutes with standard deviations of 14.6 and 95.7.

# Self-reported Injury

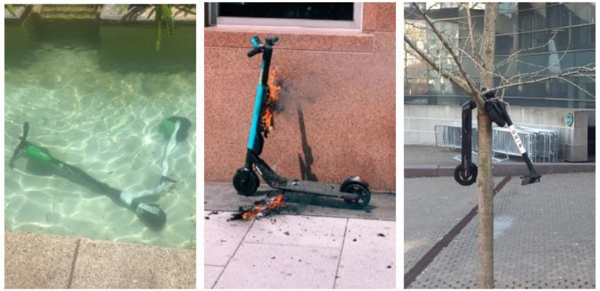
TABLE II: Self-reported injury categories

| Head (22.88%) | | | | | Trunk & Hands (27.45%) | | | | | Leg & Feet (**49.67%**) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Chin | Eye | Mouth | Nose | Others | Arm | Elbow | Finger | Hand | Others | Ankle | Heel | Knee | Thigh | Others |
| 5.23% | 7.19% | 5.88% | 5.88% | **11.76%** | 8.50% | 5.88% | 2.61% | **11.76%** | 0.65% | 11.11% | 0.65% | **24.84%** | 3.92% | 10.46% |

- **Knee protective gears** are required because of their highest injury frequency in all body parts.
- **Fingerless gloves** can be a good choice for riders to avoid hand bruises, the second most common injuries, and enable touching smartphone screens at the same time.
- **A helmet with chin protection** is a must because over half of the reported chin wounds were very serious.

# Parking Behaviors

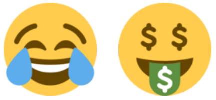
- 37.39% e-scooters were docked at right places properly, and the rest **62.61% were in wrong places**.
- Among those e-scooters parked improperly, 34.78% were parked in the middle of sidewalks; 4.78% were placed indoors; 5.65% were vandalized; and 17.39% were parked in other wrong areas.
- **Blocking sidewalks** was the most common improper parking behavior.
- **Vandalism**.



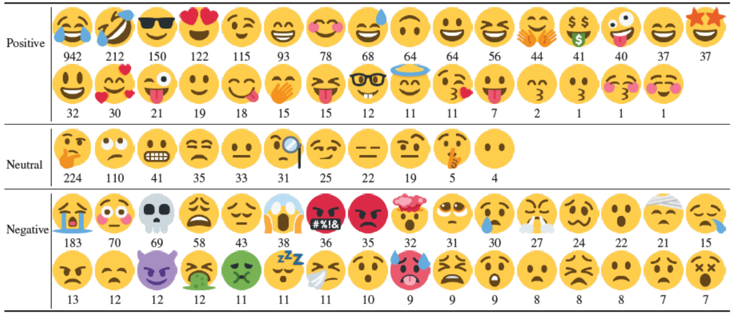
(a) Under water (b) On fire (c) Up in trees

# Emotion Analysis

- **Emoji**: 62.6% positive, 16.2% neutral, and 21.2% negative
  - ❑ Positive



  - ❑ Negative




- **Emoticon**: the positive emotions override the negative ones

| | |
|---|---|
| Positive | :) 490 :3 467 ;) 137 :-) 87 8) 79 :p 35 ;-) 33 :b 16 *) 9 :* 8 =) 7 :^) 6 x-p 6 :-)) 4 :] 3 |
| Negative | :/ 325 :( 321 :\ 245 :-( 22 :o 18 :-/ 14 :$ 10 :c 9 8-0 6 :[ 3 :{ 2 =\ 2 :-c 0 :-¡ 0 :¡ 0 |

- **World cloud**


(a) Positive word cloud (b) Negative word cloud (c) Positive and negative word cloud

# Limitation and Future Work

- **Data Bias**
  - Twitter user demographics are skewed
  - Not all shared e-scooter riders are Twitter users
  - Not all Twitter users tweet their opinions on shared e-scooters
- **Beyond an Overview of Shared E-scooter Usage**
  - Investigate shared e-scooter usage at the state/city level
  - Further explore specified aspects of share e-scooter usage, e.g., injuries, parking behaviors
  - Profile the dynamic changing and evolvement of shared e-scooter usages
  - Data and model fusion (e.g., third-part data, and expert-approved simulators)

# Conclusion

- Leveraged massive volumes of heterogeneous Twitter data, including text, @mentions, GPS data, general photos, screenshots of e-scooter apps, emojis, and emoticons, to study e-scooter ridesharing services on a large scale.
- After performing a comprehensive data preprocessing to remove noise and reduce false positives, we summarized 12 popular topics using the LDA topic model.
- For each of the extracted topics, we reported the profound insights and patterns, such as the popularity in different cities, the gender gap of riders, e-scooter market shares, transaction information, injury types, parking behaviors, and emotions from the public.

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# Thank you!

# Q&A