Crowd-sourcing Micro-mobility Parking Violation Reporting – User Interface Design Motivation and Analytical Opportunities from Data Collected

Chintan Pathak
Department of Civil and Environmental Engineering
University of Washington
201 More Hall, Box 352700,
Seattle, WA 98195-2700
Tel: 206-543-2390 Email: cp84@uw.edu
ORCID iD: https://orcid.org/0000-0002-1480-0856

Borna Arabkhedri
Department of Civil and Environmental Engineering
University of Washington
201 More Hall, Box 352700,
Seattle, WA 98195-2700
Tel: 206-543-2390 Email: bornaa@uw.edu
ORCID iD: https://orcid.org/0000-0002-3872-9820

Don MacKenzie, Corresponding Author
Department of Civil and Environmental Engineering
University of Washington
201 More Hall, Box 352700,
Seattle, WA 98195-2700
Tel: 617-452-4771 Email: dwhm@uw.edu
ORCID iD: https://orcid.org/0000-0002-0344-2344

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ABSTRACT

A surge in shared micromobility services has been accompanied by an increase in vehicle parking violations and associated public complaints. Most micromobility vehicles are unable to automatically detect a parking infraction, residents do not have a unified method of reporting the parking violations of vehicles, and regulating agencies struggle to handle the volume of incoming reports. This paper introduces a shared micromobility parking infraction reporting tool that is geo-sensitive and utilizes the popular features of a user's smartphone to deliver high-quality actionable reports to the companies and cities. The tool was informed by interviews with local government workers responsible for overseeing micromobility in their communities, and is intended to streamline and standardize the process for users to report micromobility parking problems. Copies of reports are stored in a database and can be viewed through a web-based dashboard. The paper closes with some illustrative analyses based on data collected in Seattle, Washington and Portland, Oregon.

Keywords: micromobility, bikesharing, scootersharing, parking infractions, crowd-sourcing.

INTRODUCTION

Massive private investment in micromobility[1] companies has made bikesharing and scootersharing services available in many cities at a low price point. The low barrier to entry has allowed many people to try these services, and to use them on a regular basis. All too often, misuse and abuse go hand in hand with use, and micromobility is no exception. Vandalism has been a documented issue with bikeshare (*1*), sometimes serious enough to cause the service to shutdown (*2*) (*3*). Lack of oversight and regulations led to vehicle abandonment in the early days of dockless bikeshare (*4*). While a key advantage to users of dockless micromobility is the ability to "park anywhere", wherever and whenever you finish a trip, improper parking is a leading complaint about dockless services (*5*).

Cities usually have provisions in bikesharing and scootersharing permits for reporting improperly parked vehicles, as well as time limits within which reported problems should be resolved. However, without data about where the parking infractions are happening, whether they are being reported, and whether the bikeshare companies are resolving them in a timely manner, cities have a hard time in enforcing their regulations (*6*) (*7*). Concerns over problems with parking are also responsible for delaying or limiting the scale of dockless services in some cities, which limits the utility of these services to travelers.

At present, cities use a variety of approaches to collect information regarding bike and scooter parking infractions. The methods currently in use include reporting to the city or directly to the offending companies, in most cases by phone or email. Further, there is no way to track whether the companies are resolving complaints about infractions in a timely manner.

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[1] Micromobility, in transportation, is the umbrella term representing various modes like bicycles, e-bikes, electric scooters etc. (*32*)

With existing technology it is nearly impossible for micromobility operating companies to know when one of their vehicles is improperly parked. The telematics systems on shared bikes and scooters tend to be somewhat imprecise, relying on GPS. The nature of parking rules in many cities (e.g. those relating to parking on hardscape or maintaining ADA access) is such that the difference between a legally and illegally parked vehicle can be a matter of feet, or even inches. At the same time, the number and dispersion of these vehicles makes it impractical for operators to manually monitor them. Reservation apps from operating companies often have a feature to report vehicle issues including parking infractions. However, the issue reporting is limited to the particular company's vehicles. Moreover, it requires downloading an app, which may not be possible or appealing to someone who merely wants to report a problem.

Citizens, especially those who are elderly or disabled, who do not use the micromobility vehicles are particularly inconvenienced by them when these vehicles are improperly parked. Cities are dealing with the problem of improperly parked vehicles and subsequent public complaints in different ways. However, in the absence of a unified medium to report the parking violations, the problem is less likely to be addressed and understood.

Goals & Objectives

This paper reports on the development of a mobile web app that streamlines the reporting of parking violations of dockless scooters and bikes, relaying data to the company(s) responsible and/or local governments while generating a data set that can support a variety of research questions. Mobile user-interface design and motivation is discussed. The report submission process through the reporting app is explained. Further, some field data collection results and exploration is presented.

REVIEW OF PREVIOUS WORK

Citizen-sourcing or crowd-sourcing

Crowdsourcing can be a valuable means of collecting information and can lead to solutions smarter than the smartest member given that each individual is able to formulate their response without knowledge about other responses (*8*). Studied recently at scale (*9*), the crowd consistently out-performed its constituent members, though showing the crowd's current consensus to the respondents was shown to degrade the overall performance. Applied at smart cities for ideas generation, it was found that crowd-generated ideas scored higher on user-benefit though lower on feasibility compared to expert-generated ideas (*10*).

Types of Crowdsourcing

Crowdsourcing processes may involve preselection of contributors, and might allow or restrict access to peer contributions. The contributions are then aggregated and then subsequently optionally rewarded. Based on this process guideline, the crowdsourcing processes can be qualified as (*11*): integratively sourced without remuneration (for example: Facebook, YouTube, Wikipedia, OpenStreetMap etc.), selectively sourced without crowd assessment (for example: InnoCentive Challenge Center, Netflix Prize etc.), selectively sourced with crowd assessment (for example: Atizo etc.), integratively sourced with success-based remuneration (for example:

Android marker, iStockphoto etc.) or integratively sourced with fixed remuneration (for example: Mechanical Turk).

Crowdsourcing in Transportation

The use of crowdsourcing for transportation applications has been established, whether it is finding an optimal route while driving using Waze (*12*), or cheapest gas using GasBuddy (*13*). One commonality shared by the successful crowdsourcing platforms is that they have a potential to be self-sustainable, at least in terms of data, as the data producers are also data consumers. When people are not naturally motivated to contribute their data, issues like privacy, incentives, and quality of submissions become major concerns (*14*).

Crowd-sourced Issue Reporting Platforms

There are several crowd-sourced issue reporting platforms, specifically targeted towards collecting information related to municipal issues around the cities. Key among them are: SeeClickFix (*15*), PublicStuff (*16*), FixMyStreet (*17*), ConnectedBits (*18*) and OurStreets (*19*). For the citizens, the platform provides a mobile application that allows reporting of issues around the cities ranging from potholes to abandoned vehicles to leaking pipes and more. For government agencies, the platforms provide management and analytical portals as well as integrations with other analytics software. The cities can customize the applications per their local policies, regulations and priorities, and advertise the app to the citizens.

JURISDICTION MANAGER INTERVIEW SUMMARY

To better understand how jurisdictions currently manage micromobility complaints and what requirements they find necessary for a parking reporting application, the authors conducted interviews with employees of six different jurisdictions/agencies. The interviewees consisted of four cities, an unincorporated urban area governed by a county, and a university, which all had an active, recent, or upcoming micromobility program. The authors, received insights regarding the way these agencies currently receive, handle, and resolve parking violation complaints. The authors, furthermore, asked these stakeholders about the key data that are important for a parking violation reporting application to report, and noted some of the challenges they identified about micromobility parking in their cities. These jurisdictions represent a diverse set of characteristics (e.g. diverse population size, land area, population density, and government type). Table 1 shows a comparison of these regions by the mentioned characteristics.

Table 1: Characteristics of the interviewed jurisdictions

Region	Population (2018)	Land area (mi^2)	Density (thousand people per mi^2)	Government type
City A	744,955	83.9	8.9	Mayor-council
City B	219,190	59.3	3.7	Mayor-council
City C	147,599	33.5	4.4	Council-manager
City D	67,678	16.3	4.2	Mayor-council
Unincorporated Region A	15,852	2.2	7.1	Council-elected executive

University A	N/A	1.1	N/A	N/A

It was found that each jurisdiction currently handles parking complaints in a different manner. City A had already developed a mobile app which they used to receive general city complaints from residents. They had then recently integrated micromobility issue and parking violation reporting into their app. Every time a resident submits a report, their app generates a ticket number, sends to the vendor, and the vendor has to close the ticket within 24 hours. City B used 3-1-1 call records to receive complaints from residents regarding their micromobility program. However, they also noted that it was possible reports were being sent directly to the companies, so the city did not have any record of them. Therefore, they suggested that a method for keeping records of these reports would be good for the city. City C previously used to ask residents to contact the companies directly to report any issues. However, the city's Transportation Department later developed a web portal and mobile app (which was never utilized) to directly report issues to the city. They also accepted phone calls and emails from residents. City D asked residents to contact the micromobility company directly to report parking issues. Unincorporated Region A did not have an active program at the time of the interview but had authorized a new pilot program to be launched and had finished the vendor application process. They required a channel to communicate directly with the general public and seek their input regarding scooter parking, and they claimed that an app which helps generate parking violation reports from the public would be useful for their program. Finally, University A mentioned that they receive bikeshare complaints through a dedicated university email. After the email is received, it is forwarded to their counterparts in the bikeshare companies, and each issue should be resolved within 2 hours.

The authors then asked them to identify the set of key data or features that constitute necessary information for their agencies, which should be collected about parking violations. The question was framed in the context of what data or features would an application which aims to collect parking violation reports from residents require. Table 2 shows the set of key data or features which the agencies suggested. They suggested that some of these data be mandatory while others can be optional.

Table 2: Key data/features for parking violations suggested by agencies

Suggested data for parking violations	**City A**	**City B**	**City C**	**City D**	**Unincorporated Region A**	**University A**
Timestamp	●	●				●
Geolocation	●	●		●		●
Photo	◊	●				●
Device ID (QR code)	◊				●	●
Company	●					
Description of problem	◊	●[1]	●[1]	●		
Level of frustration		◊				
Priority of violation	●	●			●	

Send confirmation once issue is resolved			◊	◊		

●: required feature
◊: optional feature
[1] suggested a pre-populated list of violation descriptions

There were a number of other features mentioned by some agencies such as:

1. Asking if an issue is recurring, since sometimes people report a problem only if they see it being repeated multiple times.
2. Asking if the resident resolved the problem on their own.
3. Asking if the person is a repeat reporter or keeping history of each user's reports.
4. Giving confirmation once an issue is resolved since some residents may desire this.

Some agencies brought up several concerns as well regarding parking violations. A summarized list of these concerns are mentioned here (a number of them were mutual among multiple agencies):

1. There needs to be a way to prioritize different violations. Different complaints require different categories and levels of responses (e.g. a bike blocking the sidewalk requires immediate action)
2. QR code scanning presents accessibility issues – vision limited users may have trouble finding the QR code and reporting it as part of a parking violation report.
3. How to send sending parking violation reports to vendors was a concern. A question was raised of whether there is a standard for reporting to companies?
4. In some cities, many parking complaints are made by a small group of people. Therefore, certain people are likely to overuse these platforms.
5. In areas where multiple jurisdictions with different vendors are located close to one another, some bikes end up in different jurisdictions where they are not permitted. Rules, company response times, and violation reporting methods are different in each area; therefore, a single app for multiple regions with region-sensitive violation and company lists may be a good solution.

MISPLACEDWHEELS

System Overview

Our team developed a mobile web application (*20*) to aid in crowdsourced report generation for parking violations of shared micromobility vehicles. The app, currently implemented under the name MisplacedWheels, allows users to easily collect and report essential data to a company whose bike or scooter is improperly parked. The data reported include:

- Vehicle location, automatically detected by the user's smartphone
- Type of problem (e.g. blocking ADA access, not upright, outside of designated parking area)
- A photo of the vehicle showing the problem
- Optionally, a vehicle ID number (read from a QR code or barcode on the vehicle)

Data can be reported directly to the company responsible (predicted based on the vehicle ID and QR code, confirmed by the user) using an automatically generated email.

The system is designed with 3-tier architecture as shown in Figure 1. The 3-tiered architecture allows for separation of concerns and development can proceed in isolation. To keep the design simple, the frontend was designed using HTML, CSS and JavaScript. An Nginx (*21*) web-server is used to reverse proxy a NodeJS (*22*) application. PostgreSQL (*23*) is used for a relational database. AWS EC2 is used to provision the web-server and AWS RDS is used to provide a PostgreSQL database. Further, to ensure scalability and maintainability, the app follows the 12-factor methodology (*24*).

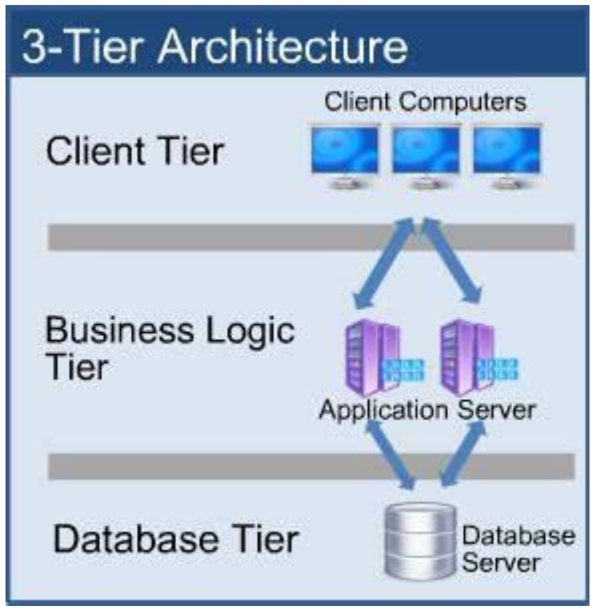


Figure 1: System Architecture

User Interface Design

Figure 2 shows the MisplacedWheels report submission process. The user starts by providing a location of the bike. The next step is classification where the user determines what kind of infractions are observed and which company the vehicle belongs to. Finally, the user can do vehicle identification by providing the specific ID for the vehicle.

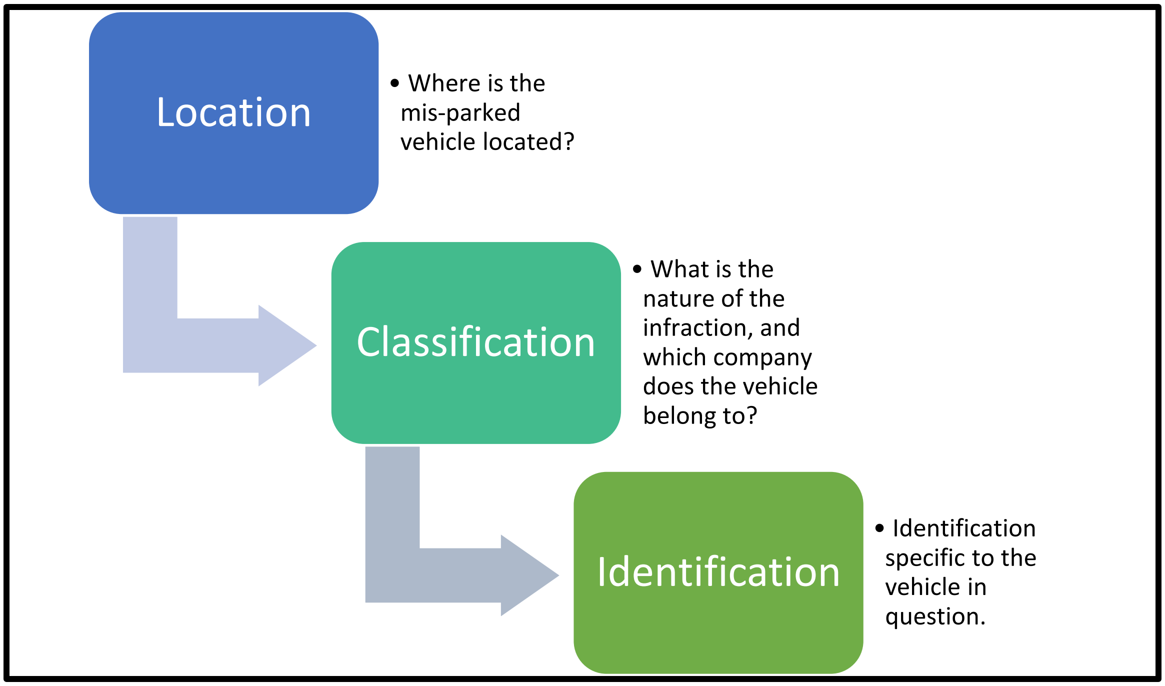
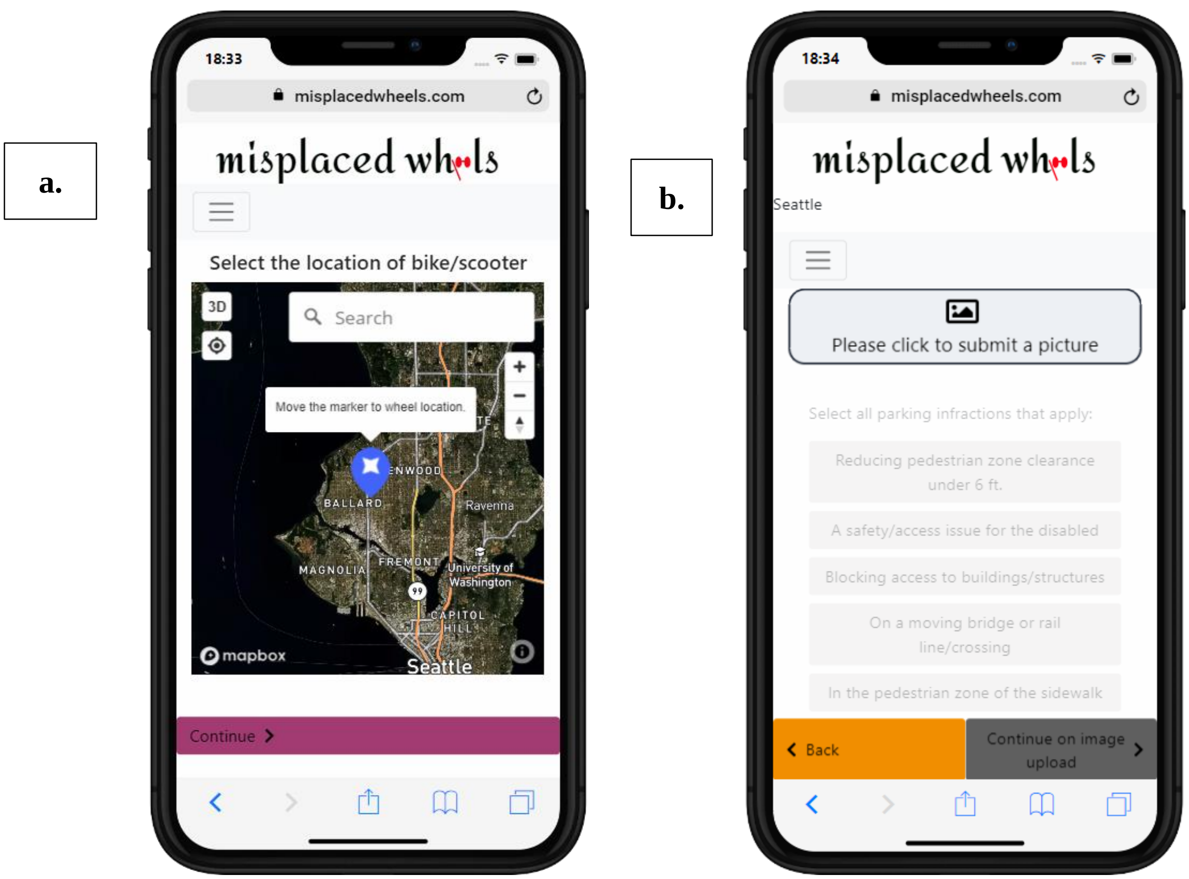


Figure 2: MisplacedWheels report submission process



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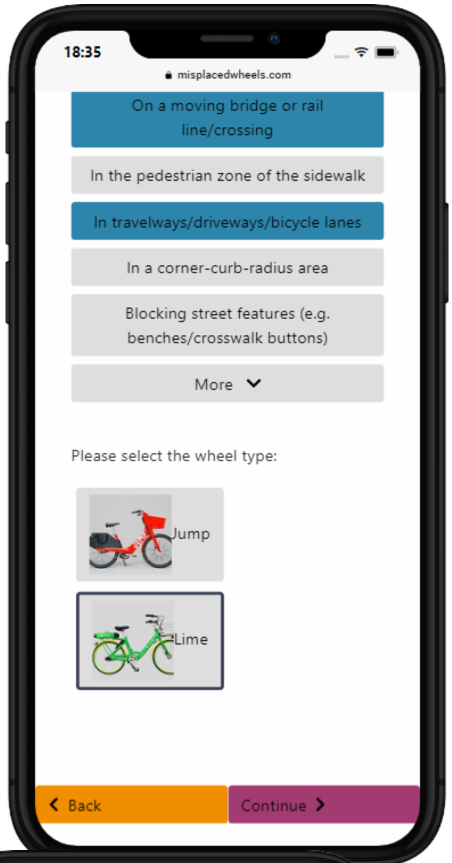

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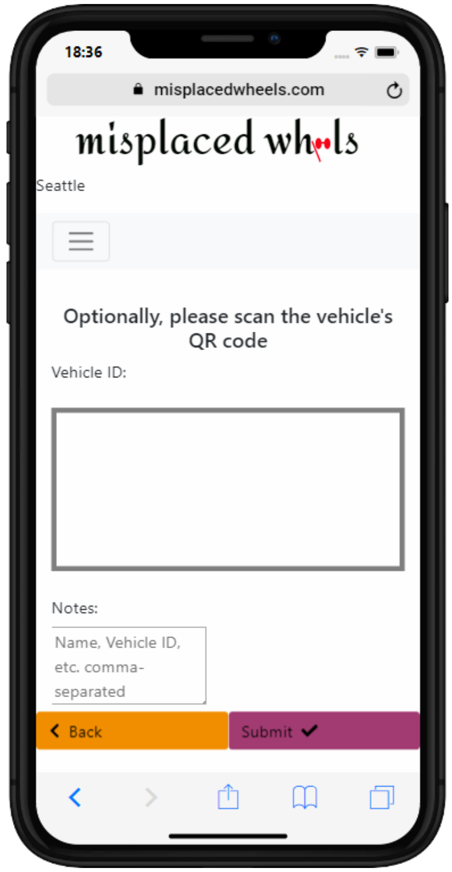

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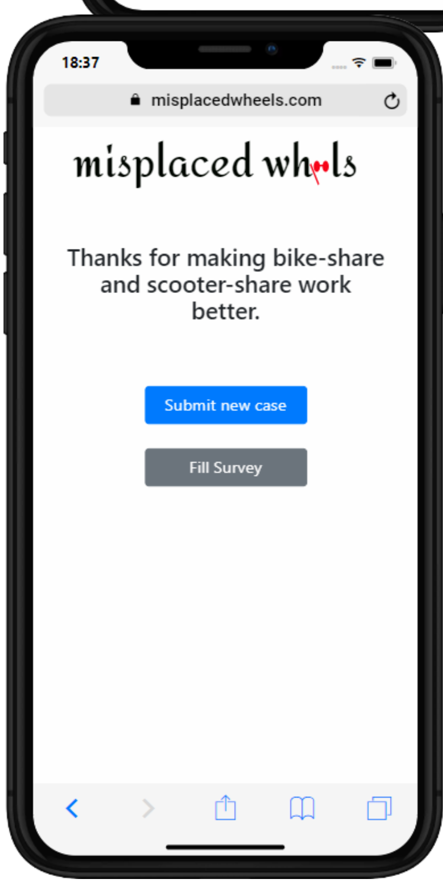


Figure 3:

a. **Location tab**: Type the name of the street and/or move the marker to the exact location of the mis-parked vehicle.
b. **Classification tab (top):** Submit a photo by taking one with the camera, or upload an existing photo.
c. **Classification tab (bottom):** Select all the parking infractions that apply and scroll down to select the company that the vehicle belongs to.
d. **Identification tab:** Optionally, scan the QR code from the vehicle and optionally enter other notes related to the vehicle.
e. **Success Message:** Upon successful submission of a report, a thank-you message is shown along with an option to submit another report or provide feedback about the app.

Figure 3 (a - e) show the various views as a report is submitted. The user selects the exact location of the vehicle starting from the initial location. The initial marker location is the GPS provided location if the GPS exists in the device and the location is shared with the web-app. In the absence of GPS acquired location, the initial location is approximated from the IP address of the device. Clicking the continue button takes the user to the classification tab.

In the classification tab the user can upload an image of the infraction. The user is shown a location-sensitive list of infractions and the companies. The user can then select all the parking infractions that apply for the inappropriately parked vehicle based on the local government's regulations. Higher severity infractions are shown at the top. The exact infraction types, associated severity, and the list of companies in the city can be customized as per the requirements of the city and dynamically updated to change if and when regulations are updated or micromobility service providers change. The user can only proceed to the next screen when an image has been uploaded, at least one parking infraction is chosen, and one company is chosen.

Finally, on the identification tab, if the user's device supports the QR code reader, then a QR code on the bike or scooter can be scanned to provide a unique ID for the vehicle. Text can be added as notes if required with the report. Clicking the "Submit" button logs the report in the database and the user is given an option to submit further reports, or provide feedback.

Process to Add Support for a New City

A unique feature of MisplacedWheels are the customized lists of infractions and companies, which are tailored based on the location of the report. This feature implementation requires a careful database design. A relational database is used that contains tables for "cities", "companies", "infractions" etc. A cities tables including the vector boundary of the region is the current preferred method of geolocation instead of reliance on an online mapping service like Google Maps or HERE as sometimes the jurisdictions with custom policies can just be a small part of a city or other public agency; as such it might be hard to decode the jurisdiction from the address alone. Next, we need to work with the city to arrive at the customized list of infractions and associated severity. Currently, the list shown in MisplacedWheels for the supported jurisdictions has been generated by summarizing the regulations and assigning a severity in the range of 0 to 10, 10 being the most severe, like blocking ADA access. Finally, the list of companies and associated vehicles need to be added to the respective tables.

Using MisplacedWheels for Parking Audits

In addition to its use by the general public for reporting parking violations of shared micromobility vehicles, the MisplacedWheels app can also be used to log data in an audit of parking rules compliance. To allow this, the infractions list also includes a "No issue" option, for logging reports of vehicles that are in compliance with all parking rules. To improve data quality, selecting "No issue" automatically deselects any previously selected violations, and vice versa.

MISPARKEDREPO

System Overview

Our team also created a repository, MisparkedRepo, (*25*) that provides a dashboard for viewing and analyzing the reports submitted using MisplacedWheels. MisparkedRepo is an R Shiny app hosted behind an Nginx server on an EC2 machine. MisparkedRepo connects to the database and collects all the reports submitted so far. R Shiny was chosen for dashboard creation as it has good support for map interaction and a plethora of in-built statistical functions.

User Interface Design

Figure 4 shows the user interface of the MisparkedRepo home tab. A table on the left shows all the submitted reports. The reports in the table can be filtered using the filters for all columns or by entering a search term. The map on the right shows circle markers indicating the locations of the submitted reports. The map is overlaid with a heatmap denoting the density of the submitted reports. The reports can also be filtered by drawing a rectangle or a polygon on the map to demarcate a specific region of interest.

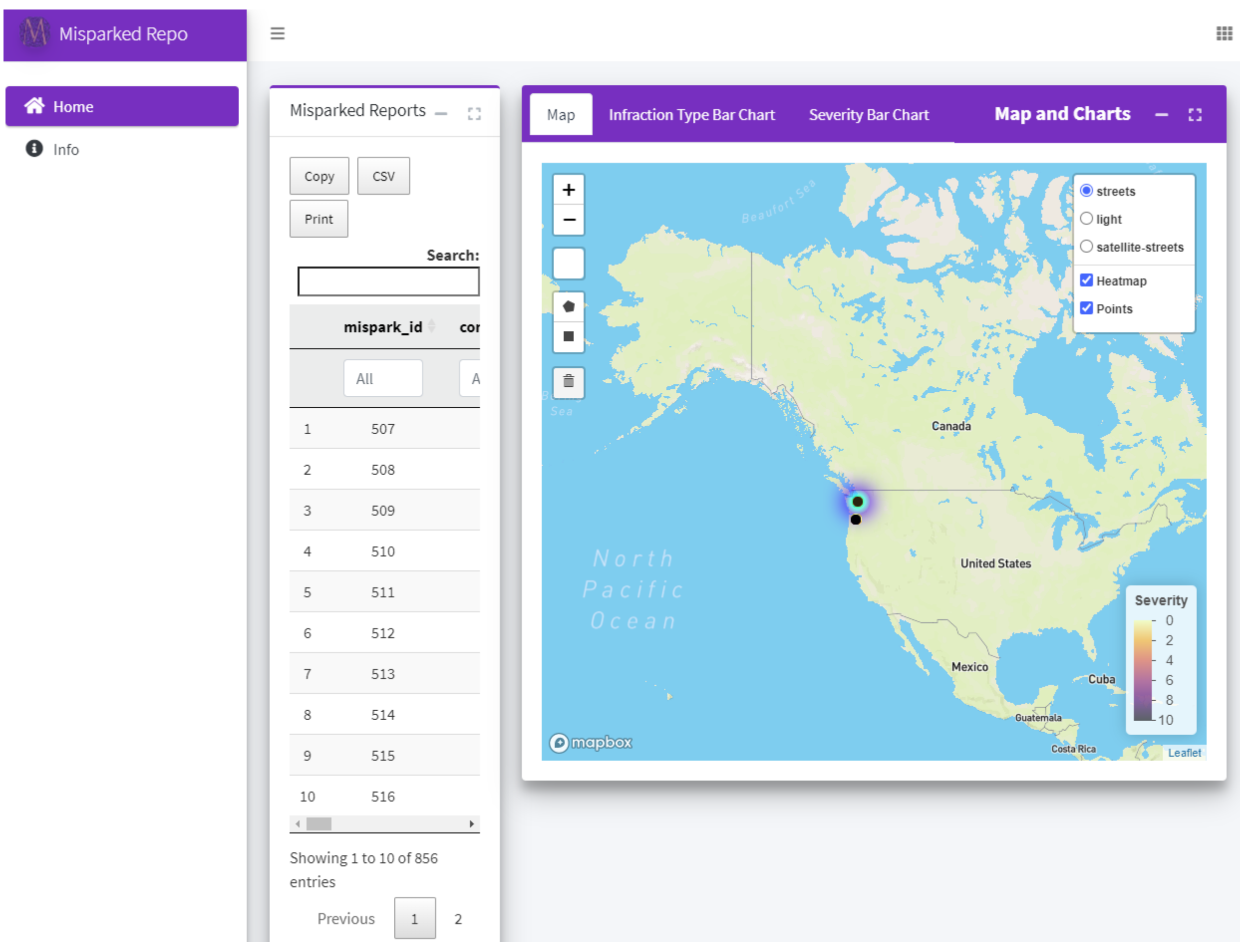


Figure 4: MisparkedRepo home tab view showing the table of submitted reports and map

Figure 5 shows the "Infraction Type Bar Chart" tab which shows the frequency of various infraction types. Figure 6 shows the "Severity Bar Chart" which shows the frequency of infraction severity.

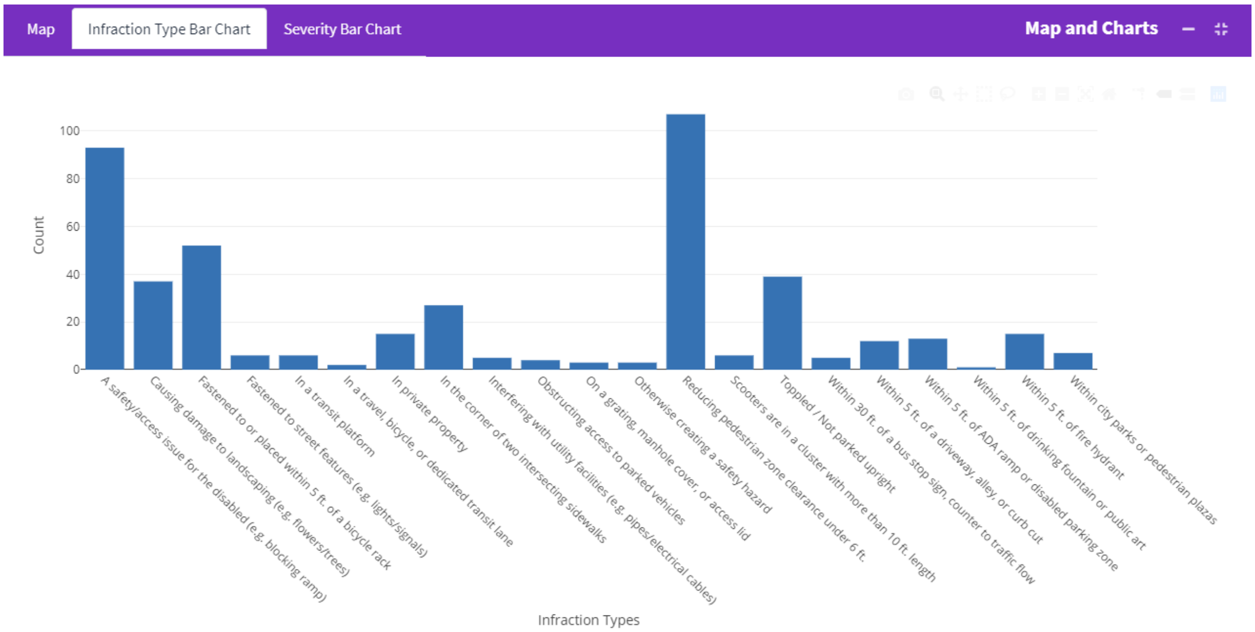


Figure 5: Infraction Type Bar chart showing the frequency of various infractions.

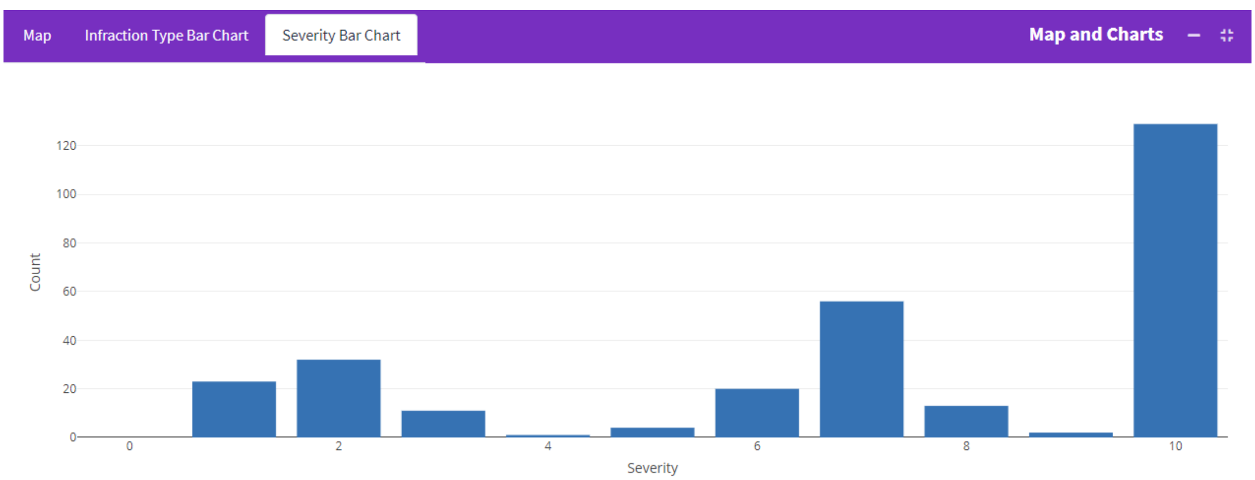


Figure 6: Severity Bar chart showing the frequency of infraction severity.

DATA COLLECTION AND EXPLORATION

Data Collection

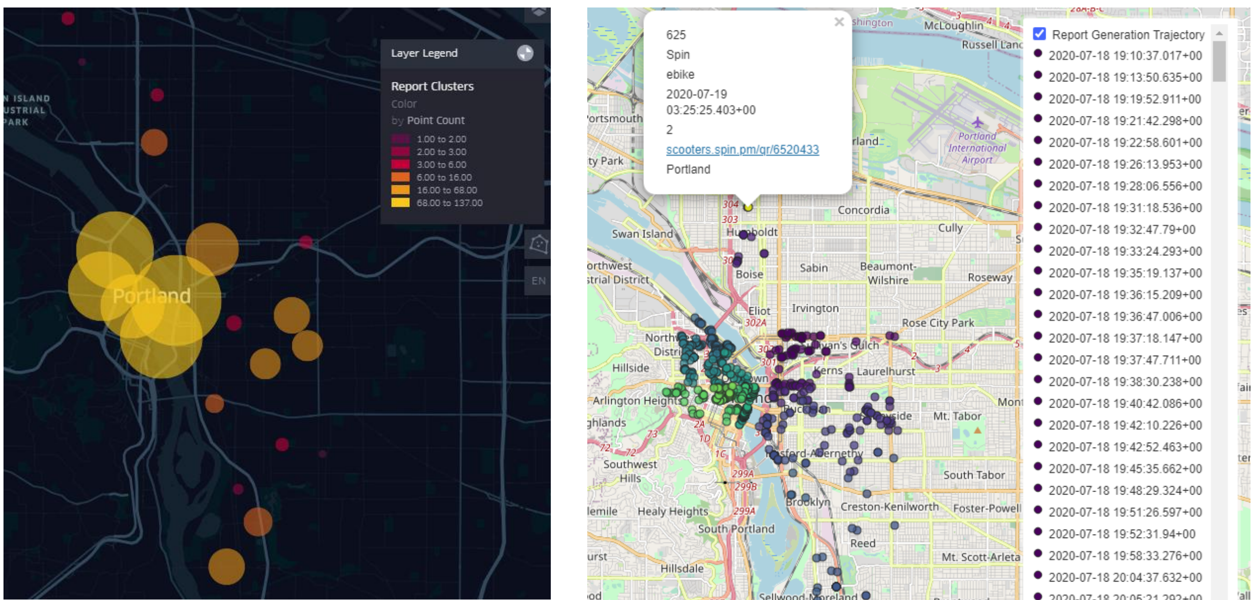
As part of the MisplacedWheels app and MisparkedRepo portal testing in field conditions, data collection was performed in Portland, OR between 18th July 2020 and 21st July 2020 and in

Seattle, WA between 22nd July, 2020 and 24th July, 2020. The collected data can be viewed in MisparkedRepo.

Data Exploration

Figure 5 and Figure 6 show charts for Portland for infractions with non-zero severity. Similar charts can be easily generated by filtering "Misparked Reports" table in MisparkedRepo portal for city and severity. The database can be connected to visualization platforms like QGIS (*26*) for further analysis.

Figure 7a, generated by importing the data in Kepler.gl (*27*), shows a visualization of clusters of submitted reports (an interactive version hosted here (*28*)). Figure 7b shows the report generation trajectory (a chrome-tested interactive version here (*29*).



a

b.

Figure 7 a. Report Clusters in the City of Portland generated using Kepler.gl
b. Report Generation Trajectory in the City of Portland using QGIS.

Figure 8 shows the evolution of average infraction severity in a region over time (interactive version here (*30*)). There is some prior evidence that vandalism and as a result parking violations would go down over time (*3*). This analysis over time can help to find areas involving high severity parking infractions. Figure 9 shows the 50-ft contour map of Seattle (*31*) overlaid with the density of reports. It can be observed that micromobility vehicles and reports are more popular at lower elevations than higher.

Figure 8 Report Severity Evolution

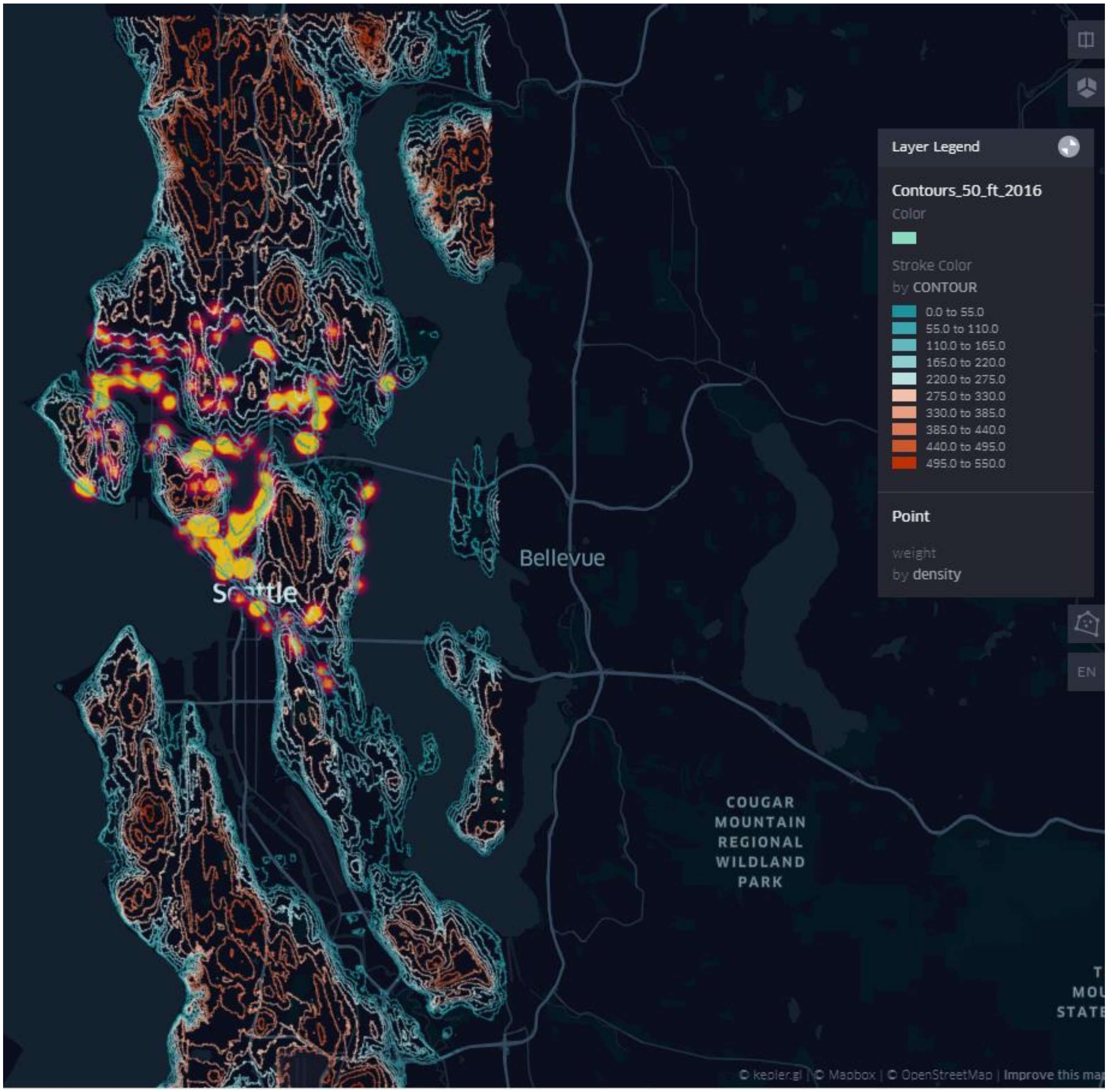


Figure 9 Seattle Contour Map overlaid with Report Density Heatmap

SUMMARY

Micromobility has potential to reduce greenhouse gas emissions by reducing the car trips by supporting transit and other shared modes. For citizens who do not use micromobility, the cities will need proper infrastructure to deal with complaints. While several cities are updating their 3-1-1 offerings to include an option to report parking violations of shared micromobility vehicles, the authors believe that a light web-app can be used to collect reports. A web-app reduces the burden of installing anything on the device and therefore is fast and instantaneous to use. No personal information is sought or collected, thereby alleviating privacy concerns. Some quality checks are enforced, like compulsory submission of image, and selection of at least one company and at least one infraction allowing for greater confidence in the submitted reports. Further, a design and experience focused on micromobility reporting allows for smoother and friendlier experience, all of which are vital for public engagement and participation. The provided dashboard allows the stakeholders to quickly view the submitted reports and draw actionable insights about what type of infractions are occurring and where. This in turn can help in finding systemic issues, if any, in the current micromobility regulatory framework.

FUTURE SCOPE

The application architecture can be modified to include Kubernetes and Docker containers to allow the application to scale. An online machine learning pipeline is in development that does object detection in the submitted images. This will ensure that users are prompted if the submitted image is not of a good quality or does not contain a micromobility vehicle. The object detection framework can be extended to perform "company detection" alleviating the need for the users for figure out what company the vehicle belongs to. Other media types like audio and video can be accepted in future to complement or supplement the infraction image. "React" can be used on the frontend instead of VanillaJS, which can lead to more readable and maintainable code. For the backend, a micromobility-manager has been envisioned that can aid the cities in dynamically managing the policies and associated geofences, infractions and companies.

AUTHOR CONTRIBUTION STATEMENT

The authors confirm contribution to the paper as follows: application conception, and review: Don MacKenzie.; application development, and draft manuscript preparation: Chintan Pathak; market research, data collection, draft manuscript preparation and application testing: Borna Arabkhedri. All authors reviewed the results and approved the final version of the manuscript.

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