Developing Data Collection Systems to Support Community-Driven Integrated Mobility Services

Mobility21 Project ID #378

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FINAL RESEARCH REPORT

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Participants

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Problem Statement

The goal of this project was to support community-driven design and deployment of mobility systems and services. Our objective was to develop and test methods for municipalities to support community-driven design of transportation and mobility systems that are more accessible, sustainable, and equitable. Furthermore, we aim to build systems to collect community data on the use and impacts of such transportation and mobility services.

Working with our partner at the Department of Mobility and Infrastructure our research activities focused on two kinds of micromobility recently introduced to Pittsburgh: 1) electric scooters and 2) a pilot of Personal Delivery Devices (PDDs, aka sidewalk delivery robots) within the Bloomfield neighborhood. Our goal

Approach and Methods

We proposed to research this topic by:

- Developing tools to allow the collection and analysis of public discourse to understand perceptions and experiences with PDD and micromobility solutions.
    - To capture public discourse, we developed a social media scraper to collect Twitter postings related to electric scooters.
- Conduct Public observations of PDDs deployed in Pittsburgh.
    - We attended online community meetings held by DOMI and the Bloomfield Development Corporation
    - We conducted field observations of PDDs deployed in Bloomfield
    - We conducted intercept interviews with people on the street who interacted with the PDDs in Bloomfield
    - We conducted interviews with key stakeholders of the PDD pilot including with members of DOMI and the PDD service operator, Kiwibot
- Develop feedback systems and data collection devices for use on and around delivery robots and micromobility transit hubs.
    - We engaged a team of independent study students to test lightweight methods for collecting community feedback
    - PI Martelaro's Rapid Prototyping of Computing Systems course designed and built a prototype kiosk for collecting public feedback at mobility hubs

Findings, Conclusions, and Recommendations

The remainder of the report is organized by sections and documents the study and findings as follows:

1. Analysis of Public Discourse around PDDs and Micromobility Solutions
2. Observations from PDD Pilot Deployment
3. Development of Feedback Stations and Data Collection System Prototypes

Section 1: Analysis of Public Discourse via Web and Social Media Sharing

Study

In 2021, the city of Pittsburgh Department of Mobility and Infrastructure (DOMI) helped roll out electric scooter service operated by Spin, to the streets of Pittsburgh. DOMI and our research team wanted to understand how people in the city responded to the rollout of the scooters by capturing public discourse on social media. To do this, our team wrote a social media scraper for Twitter that could capture tweets based on a set of keywords and in response to Pittsburgh's rollout of electric scooters.

The Twitter scraper was able to collect original tweets, retweets, and images from the public based on keywords related to micromobility, electric scooters, DOMI, and mobility hubs. Over the course of seven month from July 2021 to January 2022 we collected 1868 tweets. Of these, approximately 30% were relevant to electric scooters (some of the keywords such as "Spin" pulled up non-relevant tweets). We then reviewed these tweets to qualitatively understand what issues the public was speaking about online.

Findings

The social media scraping revealed two key issues:

1) Issues with where scooters were parked or ridden
2) Unavailability of scooters in Pittsburgh's South Side neighborhood

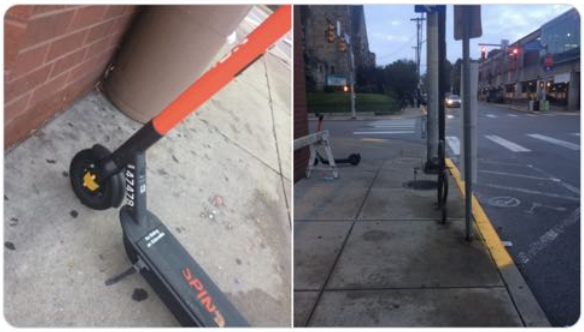
Regarding parking, a number of tweets complained about scooters being parked on sidewalks (which is not allowed) and scooters being left in odd areas. For example, this tweet discusses scooters being left on bridges because they are not allowed in Pittsburgh's South Side. Another tweet showed a video of people riding scooters on the highway.

@PghDOMI @Pittsburgh hi folks, I know you asked the scooter people to block out south side from coverage but that's lead to people abandoning them on bridges when the scooters shut off. Maybe it would be easier to allow folks to ride to their intended destinations?

Ew that's awful! Who would want to ride there, even without the barricade! (Maybe these kids that were seen riding Spin scooters yesterday on this highway in Pittsburgh?) 🤯

5:22 PM · Oct 5, 2021 · Twitter Web App

@ridespin @PghDOMI Hey folks, do you have a user-training program? Would like the user who parked their scooter on the sidewalk 5 feet from a scooter parking zone to get a notification about how to make this better. 7:30am in Pittsburgh



11:35 AM · Oct 4, 2021 · Twitter Web App

Regarding access to the South Side, a number of residents were upset about the scooters not being available.

Glad I tried it, but I have to agree: these spin scooters in Pittsburgh are a joke. $6 to ride from my house down to the hot metal bridge, only to discover you cannot cross to get to the south side (was writing to the climbing gym). Beautiful morning, but I'll stick to my bike.

9:02 AM · Sep 30, 2021 · Twitter for Android

@ridespin Any idea why only one neighborhood of Pittsburgh (South Side Flats) is blocked, and if/when it'll be unblocked? @billpeduto @SouthSidePgh @PittsburghPG @SouthSidePitt @PGHDPW @Pittsburgh

Conclusions + Recommendations

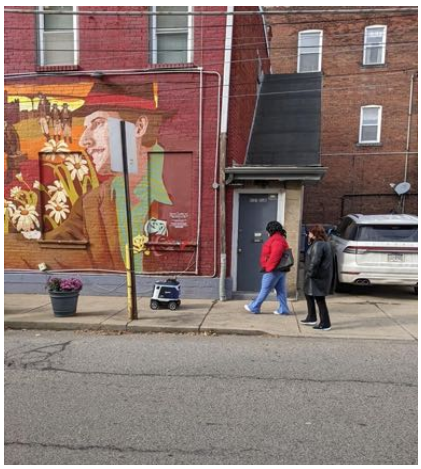
While members of the public did have complaints about the scooters, many were issues that were to be expected based on other city deployments. Parking has been a constant issue for scooters. Thus, while the social media scraping is useful for capturing incidents and gaining a sense of when and where issues occur, DOMI has been implementing different strategies to help people park correctly. Regarding access to the South Side, the area is still not open for scooters as of August 2022. For DOMI, our team recommends that they implement some form of social media tracking beyond monitoring their own Twitter. Monitoring social media can highlight issues that members of the community are having with a mobility rollout. DOMI may find that some issues can be solved with changes to policy or to the design of mobility hubs and parking areas.

Section 2: Public Observations of PDD Deployment

Study

The city of Pittsburgh Department of Mobility and Infrastructure (DOMI), supported by the Knight foundation, conducted a pilot deployment of PDDs in the Bloomfield and Garfield Neighborhoods of Pittsburgh, PA. We observed the deployment of Kiwibot delivery robots to understand how people interact with the PDDs over the course of the pilot test. We also attended community meetings held by DOMI including members of the Bloomfield and Garfield communities.

We conducted field observations of the robots mapping the sidewalks and when the robots were conducting simulated delivery runs. We captured photographs and wrote detailed field notes for analysis. We completed 25 hours of ethnographic observations over 16 days. We also conducted eight intercept interviews with pedestrians who interacted with or passed by the robots. The results of the observation study were analyzed qualitatively using affinity mapping. [1]


Findings

- Most pedestrians have little to no knowledge of PDDs. Lack of information leads to a rise in shared theories and folklore.
- There are limited communication methods between PDDs and people
- Pedestrians rarely and cautiously engage with PDDs when they become stuck and require human assistance
- Pedestrians were more likely to assist the robot when prompted through direct communications such as sounds or text
- Without direct communication pedestrians were less likely to assist and were more hesitant when interacting

Conclusion + Recommendations

Proactive communication measures could lead to increased trust and community acceptance of robots in pedestrian spaces. The use of directional, written communication and sounds encourage pedestrians to assist the PDDs when needed. There are opportunities for future research to refine the visual and auditory for better communication to receive assistance and to aid in pedestrians' comfort level in providing assistance.

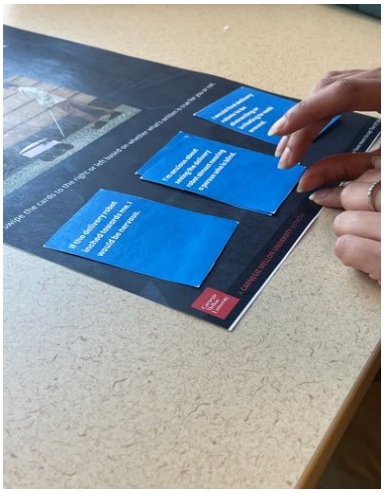
Section 3: Feedback Stations and Data Collection Tools

Part of our research goal was to also collect feedback on people's perceptions of new micromobility deployments in the city before and after a deployment in public. While survey's and social media scraping are known methods, there are limitations in how effective they are at capturing data from a diverse set of people. Additionally, surveys may not be that engaging nor will people often take a survey near a time where they have interacted with a new micromobility device such as a sidewalk robot. Our research goal for this aspect of the project was to create new methods to capture feedback from the public that would be engaging, would help explore various aspects of people's perceptions of a micromobility service, and could be deployed close to where people may have interactions with micromobility devices. We developed one set of prototypes to explore new ways of capturing feedback from community members (Study A) and another prototype for a kiosk-based feedback and information station that could be placed near mobility hubs.

Study A: Designing new activities for community feedback

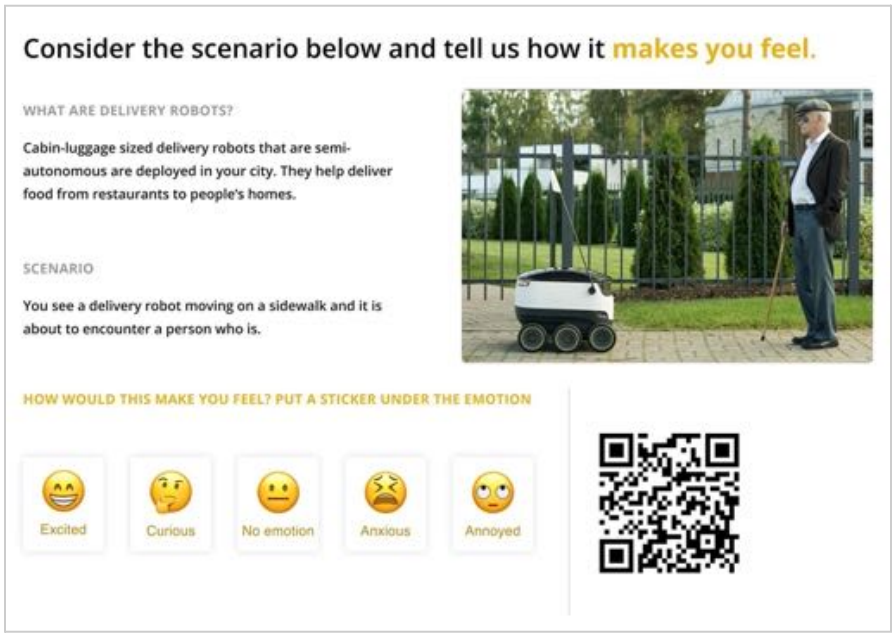
To capture a rich set of perceptions on micromobility devices from people, we created a number of prototypes to have people think about different situations with micromobility devices and to mediate a conversation on those situations. For these prototypes we focused on capturing feedback around personal delivery devices. Our goals for this work were to test a wide range of ideas to see which ones might engender better engagement and feedback from people. The following ideas were developed by a group of independent study students during Spring 2022.

"Tinder" for community feedback



This idea uses a set of scenarios about PDDs and how someone might feel that people then place to the left or right to signal that this would be true of their feelings (modeled off the popular dating app "Tinder"). For example, a scenario of a person with a cane approaching the robot might be shown. A person would then rate a card saying "If the delivery robot inched toward me I would feel nervous." The goal with this prototype was for people to rate a set of scenarios quickly and then to explain why they might feel that way about each scenario.

Emoji poster for gathering feedback on different scenarios with PDDs.



We explored an alternative way of capturing people's emotional responses to a robot scenario through a poster where someone is asked how they feel given a situation. Five emoji representing excited, curious, no emotion, anxious, and annoyed are shown. In a physical setting, people can place a sticker under the emotion they think they would feel. A QR code leads people to a digital version of the poster. Various posters of different scenarios could be placed in common spaces.

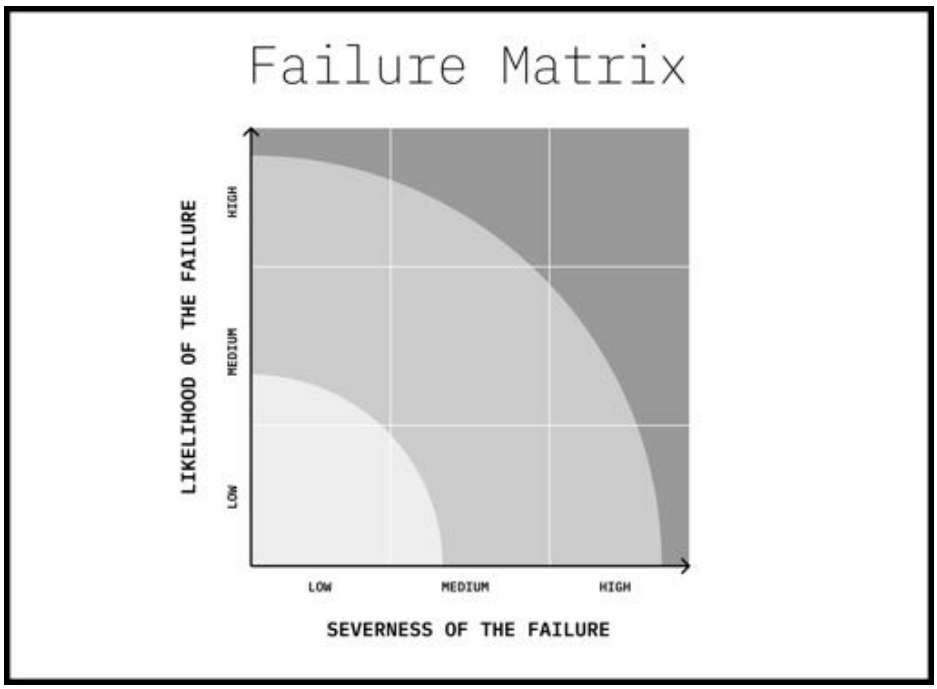
Physical survey on perceptions of PDDS

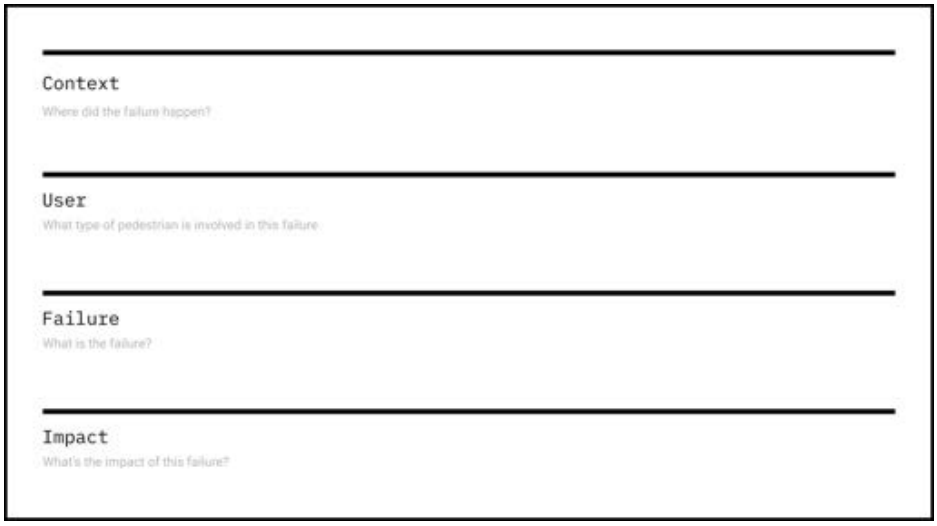
Building on the idea of capturing people's assessment of their emotions, we also developed a poster where people could rate how they would feel about encountering a PDD. We tested this prototype in a local park in Bloomfield, the same neighborhood with the PDD deployment. Paired with a digital survey, we were able to capture data about people's thoughts about the introduction of PDDs in Pittsburgh. Two students introduced people to the poster and discussed people's selections with them.

On robot flag as a means to capture data

Another idea we began to prototype was if the robot itself could be a place for people to give feedback. It is common for QR codes to be placed on robots that lead to a survey. However, we also thought that people could physically interact with the robot in some ways to give feedback on simple yes-no questions. From observations and prior work, we know that some people will "high five" the safety flag on a robot. This does not interfere with the robot's operations and so we asked if the flags might be a way to have people touch the robot and vot on a yes or no question without needing to touch the body of the robot, which most people are reluctant to do. We mocked up an idea using a foam core robot with a flag and asked people to try and "high five" the flag after reading a question placed on the robot.

Bulls Eye Failure Matrix





Another area of feedback that we wanted to explore what possible failures people could imagine happening with a PDD. Such failures might include the robot not delivering to the right location, the robot breaking down, the robot crashing and getting stuck, the robot blocking someone with an accessibility need, the robot harming someone, and someone harming the robot. To help mediate conversation on possible failures we developed the "Failure Matrix" and a set of guiding questions to help people come up with ideas and rate them on levels of severity and likelihood.

Robopoly

To further explore people's perceptions on robot failures, we developed and prototyped a board game called “Robopoly”, based on the game Monopoly. The purpose of the game is to surface downsides, concerns, and potential solutions of PDD impacts. The rules of the game below are intended to foster conversation on potential failures:

1. Player roles a dice, and moves their piece to the number of spaces indicated by the dice
2. Upon landing on a ‘location space’, the player will pick up a ‘Scenario’ card from the center of the deck.
    a. The player will then generate hazards or outcomes based on the scenario and location. Upon finishing the discussion, the player will receive the location card for that space.
3. Upon landing on a ‘Solution’ space, the player will discuss solutions for one of the scenarios that have been named
4. Upon landing on a corner “Open Mic” space, the player will be allowed to discuss any concerns, fears or excitements around PDDs.
5. The game ends when all of the location cards are gone.

Study A: Data Gathered + Analysis Description

All prototypes were rapidly tested with other students and/or with members of the public. As the goal with our prototype explorations was to quickly understand if the ideas could capture feedback and were engaging, we focused on qualitative feedback about how engaging the prototype was. We also capture the kind of feedback that we received. The student team took notes about people's experience with the prototypes and generated a set of findings.

Study A: Findings

“Tinder” for community feedback prototype

Finding	**Insight**
“It’s so fun” “It’s like Tinder” Need to still explore with a wider audience with different demographics.	The “Tinder for community” interaction and idea resonated, but needs to be tested further.
Some content from the cards aren’t applicable to Pittsburgh. They’d be more applicable to a busier city like New york.	Content needs to be contextualized to the city for most accurate results

Not all bus stops are covered and have a place for an interactive board	Location of interactive board would need to be considered and city specific
Participants are limited by the videos I show them to introduce them to the delivery robot. As a result, sometimes they are unsure which bucket to put it in.	Tinder for community might only work once deployment is rampant and large scale within a location

Emoji poster for gathering feedback on different scenarios with PDDs.

- **Finding 1 -** People will not scan QR code to answer survey, they prefer something physical to interact with
- **Finding 2 -** The emojis are a lot more attractive and eye catching than a QR code
- **Finding 3 -** The emoji were clear and gave a range of emotions for people to express themselves with

Physical survey on perceptions of PDDS

- **Finding 1** - Opinion on PDDs for food delivery: Folks have diverging opinions, but mostly indifferent or neutral. Two participants even mentioned potentially being more comfortable with food delivery from a robot rather than a human.
- **Finding 2** - Mobility concerns: Multiple people mentioned they were concerned about how it might affect folks with mobility issues, often despite their personal excitement.
- **Finding 3** - Perception of PDDs: Some people think PDDs are funny and consider them a source of entertainment. They watched videos on Twitter of them being stuck and mention vandalism but more in a novel, unconcerning way.
- **Finding 4** - Collecting feedback physically vs digitally: Feedback engagement, both physical and digital, is affected by environmental factors. Cold weather + wearing gloves led to more physical board usage - people didn't want to take gloves off to use the phone. Wind affects paper voting strips and posters. People are often walking quickly and wearing headphones, thus do not engage with the data collection.

On-robot flag as a means to capture data

- **Finding 1:** People were generally comfortable touching the robot's flag, but were not comfortable touching the robot's main body
- **Finding 2:** The flag was easy you touch while the robot was at rest, but harder to touch when the robot was in motion
- **Finding 3:** For a yes or no questions, two color flags might be easier for people to understand
- **Finding 4:** People were generally unwilling to give feedback to the robot about it's workings assuming the company to be fixing issues

Failure Matrix

- **Finding 1:** People were able to generate a wide variety of failures and situations that could cause failures. Some examples include what might happen if the robot is stuck in snow, what if the battery runs low, and what if a blind person using a white cane runs into a robot?
- **Finding 2:** People often did not think about accessibility concerts without guidance (although such concerns are important for accessibility on the sidewalk)
- **Finding 3:** People often try to start solving the problem even though the goal of the activity is primarily to surface issues
- **Finding 4:** People often would need some clarification of the robot's design and operation to start imagining possible failures. This could limit people's thinking though.
- **Finding 5:** The activity using the visual bull's eye board was hard to do online with a blind participant.

Robopoly

Finding	**Insight**
Pilot testers reported that their mental model/prior knowledge of Monopoly had affected their understanding and expectation of the Robopoly Game	The activity needs to be standalone (re: design, explanation) and should not mirror Monopoly in its entirety
Pilot testers reported that some of the components are distracting and unnecessary.	The activity needs to be simplified.
Pilot testers reported that they don't like the inconsistency in context.	Selection/Level of specificity about context should be consistent.
Pilot testers found certain Hazards to be similar (especially surrounding the device being stuck)	Scenarios need to be more diverse from one another and can include seasonal instances

Study A: Conclusions + Recommendations

Recommendations for physical data collection tools:

- Consider the locations of collecting feedback mechanism - public area with foot traffic where people may not be in a hurry may be better (i.e. parks)
- Complete data collection in neighborhoods where testing occurs - people are more likely to have seen or interacted with a deployment
- Take weather and environment into account when designing engagement mechanism - cold weather may make physical data collection preferable
- Further engagement without facilitators present should be tested as their presence could lead to actor-observer bias

Recommendations for game-based tools:

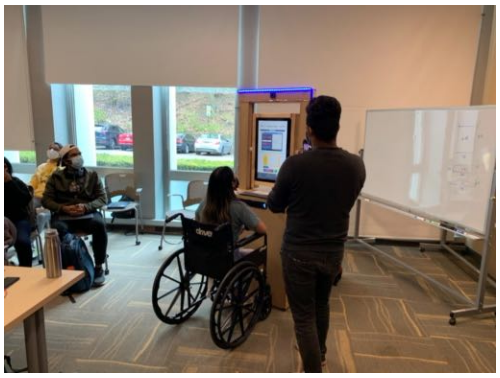
- Using metaphors of games the people know can allow people to pick up on an idea quickly. That being said they can also force people to think too much in the frame of the similar game. Care should be taken to use just enough of a metaphor to help people learn the mechanics of the activity.
- Games with visual elements should be designed so that people who are low vision or blind can still engage through verbal communication.

Study B: Designing community feedback kiosks for mobility hubs

To capture feedback near where people may interact with micromobility services, a team in PI Martelaro's Rapid prototyping class developed a kiosk based feedback station where people could provide their thoughts on different services. The kiosk requirements were to be able to collect feedback through rapid questionnaires and voice-based video recording. The Kiosk was also designed to provide people with useful mobility information so that they would be more willing to use the kiosk. The team conceptualized the design and then developed a functional prototype.

Study B: Results

The prototype kiosk was built using off-the-shelf components. A large touchscreen provides an interface that can be used to give quick survey feedback on a micromobility experience, such as riding a scooter. This is done using a set of five emoji of face from sad to happy (modeled after the "Happy or not" terminal common in airports). A QR code is also provided for people to provide more feedback via a web form. People could also select a microphone option to give spoken feedback. This feedback was recorded to the device and then transferred to a cloud data storage where the audio could be transcribed and analyzed.



The kiosk was also designed to be accessible for those in wheelchairs, with low or no vision, and to those who are low hearing or deaf. A physical keyboard included braille keys. The kiosk screen was mounted on a pivot to allow people to rotate the display so they could view it and interact with it even if in a wheelchair.

Study B: Conclusions + Recommendations

Overall, the prototype achieved the major functions for capturing feedback. The physical design is currently in early prototype stages and could be improved for better accessibility and to be easier to build. The touchscreen software was generally easy to use during internal testing, however further testing is needed by members of the public. Overall, the prototype represents a technical proof of concept that may warrant further testing with more design refinements.

Publications

1. Weinberg, D., Dwyer, H., Fox, S., Martelaro, N. “Sharing the Sidewalk: Analyzing Autonomous Delivery Robot Interactions with Pedestrians” For the workshop, “HRI in Public Spaces,” HRI 2022, Sapporo, Hokkaido, Japan.

Data

As described in the data management plan, anonymized data will be made available through CMU KiltHub to researchers with IRB approval to use the data for research purposes. All data sharing will require a data sharing agreement with CMU.