GAZE: Using Mobile Devices to Promote Discovery and Data Collection

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Abstract
Developments in citizen science, community sensing, and crowdsourcing offer the opportunity of large scale data collection of the physical world because of the ubiquity of sensor-rich, mobile devices. Despite this opportunity, large-scale data collection about physical spaces is currently not widespread because of high-effort participation. In this paper, we explore the ability for people to contribute on the go. We developed Gaze, a system that will collect information about people’s responses to physical spaces through low-effort feedback. To enable low-effort contributions for large scale data collection, we have developed a design pattern called Identify-Focus-Capture that identifies opportunities for users given current situational context, helps users to focus in on the opportunity, and captures useful data through simple actions or gestures. Through our pilot, users successfully helped collect 50+ data points about their environment, showing that useful data can be collected when the opportunity is low-effort.

Author Keywords
Physical Crowdsourcing; Community Sensing; Citizen Science; Data Collection
**ACM Classification Keywords**
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**Introduction**
Recent developments in citizen science, community sensing, and crowdsourcing suggest the possibilities of massive data collection about the natural world supported by many people. The ubiquity of sensor-rich, mobile devices inspires participatory community sensing as a promising approach to enable large-scale data collection with crowds. Recent developments in crowdsourcing and citizen science further demonstrate the ability to involve large numbers of people in data collection and problem solving.

Despite opportunities, in practice, large-scale data collection about physical environments is currently difficult and not widespread. One, participants need to be interested in contributing, and the efforts for participation may be too high. Two, related to one, is that large-scale data collection needs to be low-effort in order for participants to contribute daily and while on the go. Participation requires focus from the individual, which may be too much effort for everyday participants. Third, participating may require actively figuring out where to look, which is also too much of an ask for the participant. We hypothesize that by enabling low-effort contribution opportunities in a user's environment, we can gather useful data.

In this paper, we introduce Gaze, an approach for people to gather information about physical environments while on the go. Gaze is a backend system that collects information on people’s response to physical spaces. To do this, Gaze connects people to their physical environment by asking them a question about their surroundings, and allows for users to answer.

The main contribution of this paper is the idea of opportunistically enabling low-effort contributions to citizen science or participatory community sensing by connecting people to short data contribution opportunities while on the go.

The fundamental technical contribution of this research is a design pattern called Identify-Focus-Capture. With Gaze, we introduce Identify-Focus-Capture as a design pattern for enabling low-effort, on-the-go community sensing (see Figure 1). Identify works in the background to search for nearby physical crowdsourcing opportunities that would interest the user given the current situational context. Focus presents cues that draw user's attention to the opportunity, and Capture prompts the user to contribute by means of answering a question, taking a picture, or simply ignoring the notification. To test the effectiveness of our design pattern, we developed a user-facing iOS app to prove that the design pattern can be applied in real-world contexts.

In this paper, we first discuss related work. We then present Gaze, its design, the user-facing app FixTheCity, and associated implementation details about them. Finally, we will cover the study we performed and how it proves our hypothesis as well as opens up the potential for future work.
Related Work
Gaze is related to two areas of work: communitiesensing and mobile crowdsourcing.

Communitysensing
Communitysensing is a promising approach for involving large numbers of people to collect data in physical environments [5,6,7]. In the opportunistic model, a communitysensing application collects data passively, for example by aggregating GPS data from device-carriers to predict traffic conditions [8]. In the participatory model [9,10,11], an application specifies tasks and goals that require users taking action to collect the desired data. While collected data may be of more value in this model, the cost of collecting may deter participation. To reduce the cost of effort, Rula et al. [12] introduce crowd soft control as a mechanism for identifying nearby opportunities, so as to steer users toward informational needs while considering the cost of travel. Our work in low-effort communitysensing takes this approach further, by using people’s natural mobility patterns but identifying opportunities for contribution while on the go.

Mobile Crowdsourcing
Recent works in mobile crowdsourcing consider replacing traditional unlock screens with tasks that can be completed in seconds. For example, Twitch [1] and Slide To X [2] replace the lock screen with tasks that collect census, geographical, and personal data. These works share similar design challenges with our work in that we wish for tasks to be doable in short durations of time, but differ in that the primary goal of Gaze is to focus the user’s attention on the physical world and not on their device screens. In this way, the goals are akin to those of PhotoCity [3] and CityExplorer [4], both of which promote users to explore physical spaces and capture useful data as a byproduct. Unlike these systems whose interactions serve as the primary experience during play, we seek to enable lightweight contributions through people’s natural movements and mobility patterns.

System Description
We will now introduce our system, Gaze, detailing its iOS interface app, FixTheCity, as well as technical details and implementation.

FixTheCity
FixTheCity is a “Good Samaritan” app that allows users to make contributions to physical spaces that need attention. For example, if a streetlight is broken at the corner of two streets, FixTheCity can quickly ask users that are within the streetlight’s vicinity if the light is broken or not. The question is low-effort enough that users are willing to contribute for “Good Samaritan” points while actual data is being collected that is useful for the City of Evanston.

User Interface
Once the user is close enough to the location of a task, FixTheCity notifies them and they are presented with Google Street View of their current location, a focal point on the task, along with the question they need to answer (See Figure 2). After successfully answering the question, the user is presented with how many CityPoints they earned and the app dismisses to the background after 4 seconds. Mostly users get notifications and receive tasks, but they can also use the app at any time to see a map of nearby tasks they can complete along with their current CityPoint Score (See Figure 3).

Figure 2: Interface for Focus view in which user is presented with a question
Technical Details
Given our hypothesis, we needed to efficiently capture data about physical locations. We concluded that the data we were capturing had to either be of the user’s interest or had to be low-effort or even both. We came up with the design pattern Identify-Focus-Capture to simplify our system interaction flow into three parts.

In designing Gaze and FixTheCity we implemented each of Identify-Focus-Capture as the main features of the apps. We identify tasks near the user that have not been answered. That user focuses in on the opportunity presented. Then we capture data about the task through low-effort user interaction. We felt that the best way to carry out our design pattern in a user-facing app was through FixTheCity.

In choosing what interface to present the user and utilize Gaze’s backend functionality, we carried out needfinding to determine location based problems specifically on Northwestern University’s campus. We learned that specifically within the Evanston area, there was a delay in the fixing various objects around the city, such as sidewalks, streetlights, trashcans, and street signs. This problem fit in perfectly with the design pattern Identify-Focus-Capture that Gaze excels at.

In developing the interface we noticed that in addition to these city tasks, we could also add tasks to help Northwestern students in various ways. For example, FixTheCity users could identify quieter places on campus for study, or could identify open bike racks for others to park their bikes. By offering an incentive through CityPoints and a leaderboard, students are more inclined to help the city and others.

Implementation
Behind FixTheCity is the backend system, Gaze, which was designed and built in Rails. It offers a public API for front-end apps to plug into such as FixTheCity. Gaze tracks users through events that are updated by hitting endpoints with location data. When an event and task are close enough, they become linked together and the user is notified of the task (See Figure 4). Once a user answers the question, it becomes associated with the task. This allows us to keep track of all the answers for a given task or user. We developed an admin panel website to allow for the creation of tasks, as well as viewing answers to current tasks and the leaderboard.

Pilot
For the pilot we used undergraduate and graduate students from Northwestern University. Participants were recruited via email listservs for this study. Our observational study consisted of giving subjects our software system and allowing them to experience it throughout a weeklong period and reporting back with short written responses to a survey.

Participants were given access to download the FixTheCity app on their iOS devices for a weeklong period. They were simply asked to keep the app running in the background for the duration of the study and go about their day as usual. This encouraged users to take normal walking paths and not explicitly seek out tasks. After the study period we sent out post surveys for the users to complete based on their experiences with the app.

In addition to the post surveys, we analyzed data collected through applications logs, which included:
Which tasks were completed by which users
Time taken for users to answer the provided question
The number of tasks completed by users

To gather results on how efficient the Focus aspect of our system was, we decided to conduct a small control study to get a baseline for an amount of time needed to collect data about a physical space. To do this we had users start with their phone in their pocket, receive a notification, select the notification and answer a question without any visual or audio cues such as images or maps. These questions were very similar to those asked in FixTheCity.

Results
We had 5 subjects go through the control process of receiving a question with no context and answering it. Total time differed by subject and question, but on average it took the subjects 20 seconds to complete the task. The amount of time from initial notification to the subject looking at the screen was fairly consistent however. The variability arose from subjects drawing their attention to what the question was asking about. For example, one of the questions asked, “Is the trashcan near you full?” For some subjects there was a tree immediately blocking their view of the trashcan. They took a couple extra seconds looking for the trashcan so that they could adequately answer the question. For other subjects, they were standing directly next to the can and could quickly answer the question.

We had a total of 25 subjects participate in the FixTheCity deployment. Together, over the course of the week, they successfully gathered 50+ data points about various tasks around Northwestern’s campus. There were 20 tasks scattered across Northwestern’s campus ranging from asking about full trashcans to open bike racks to cracks in the sidewalk. The average distance between the user’s GPS location and the location of the task when the user was alerted of the task was about 30 feet. At the current stage of the system there was no way of determining if the user was walking towards or away from the task and the time of the notification. We address this as part of future work.

Another anomaly we noticed was the discrepancy in answers for one particular task. The task question asked if a specific but well-known room in the Main Library was quiet. The uncertainty arose when people were prompted with the question on floors above the task room. All of the other tasks were outside and these numbers proved the Identify part of the Identify-Focus-Capture design pattern was working.

For the Focus, we compared the average time from receiving the notification to successfully answering the question. On average, this time was 15 seconds, a 5 second improvement from giving no context whatsoever. Given that this time includes taking a phone out of a pocket or purse, unlocking the screen, and answering the question, this is a significant improvement, making the contribution even more low-effort. In the post survey we asked participants how long they thought it took to answer a question with the average being 7 seconds. This means that although it was actually taking longer, to the user it felt only as long as 7 seconds further lowering the contribution effort.
For Capture, every participant answered at least one question with the leader answering 7 questions over the course of the week. All of the questions asked were binary with a ‘yes’, ‘no’, and ‘maybe’ with ‘maybe’ being the option if the user was unable to answer the question. Of the 50+ data points only 5 of them were answered with a maybe. These results show that if the contribution is low-effort enough, data can be gathered about physical spaces through the Identify-Focus-Capture design pattern.

Discussion
While we believe our system fulfilled its goal in supporting our hypothesis and providing technical and conceptual contributions, there are still areas for improvement and future work. For instance, we only developed one user facing iOS app to prove that Gaze works with Identify-Focus-Capture. Within FixTheCity, more work can be done to ensure that users are identified and informed of tasks at appropriate times. Also Higher fidelity reports can be built from multiple lower fidelity tasks. And lastly, a larger scale deployment could further strengthen our data and prove that Gaze is a successful system for community sensing and citizen science.

References