User-Centric Crowdsourcing Approach to Improve Urban Accessibility Data Collection

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***Abstract*—While crowdsourcing is an effective method for collecting large-scale datasets, it often faces challenges related to data quality and quantity. This study employs crowdsourcing to collect comprehensive urban accessibility data, focusing on storefront accessibility information in a large city. This task presents significant challenges in terms of data completeness and quality. To address these issues, we propose a user-centric, request-driven crowdsourcing approach that gathers accessibility data based on requests from individuals who are blind or have low vision (BLV). This approach strengthens the user-volunteer feedback loop, increasing volunteer engagement and enhancing user experience. It allows BLV individuals to effectively utilize the collected storefront accessibility data for independent travel. A preliminary user study confirms the effectiveness of the proposed approach.**

***Index Terms*—Crowdsourcing, Urban Accessibility, Independent Travel, Visually Impaired, User-centric, Request-driven**

I. Introduction

In the United States, approximately 12 million individuals have some form of visual impairment, with 1 million being legally blind. People who are blind or have low vision (BLV) face numerous challenges when navigating independently [1]. These challenges include difficulties in accessing reliable information about their surroundings, which can make travel both stressful and risky.

To address these issues, we have developed a web-based application called DoorFront.org [3] to collect large-scale accessibility data of New York City storefronts using a combination of crowdsourcing, Google Street View (GSV), and artificial intelligence (AI). This application provides BLV individuals with detailed, accessible data that can significantly enhance their travel experience by reducing uncertainty and enhancing safety.

DoorFront collects relevant visual data, including the bounding boxes of various storefront accessibility data in GSV images and their corresponding geographical locations. Volunteers, particularly high school students, are encouraged to participate by visiting the website to virtually walk the streets of NYC through GSV while capturing images of storefronts. Once the volunteers capture images, our AI image-recognition system provides preliminary labeling by scanning the image for the specified criteria: door, stair, ramp, and knob. Upon discovery, the AI system will place bounding boxes of differing colors around the relevant objects. Please refer to [3] for additional details on the implementation of the AI system. Volunteers are then tasked with confirming the validity of these labels while making necessary adjustments.

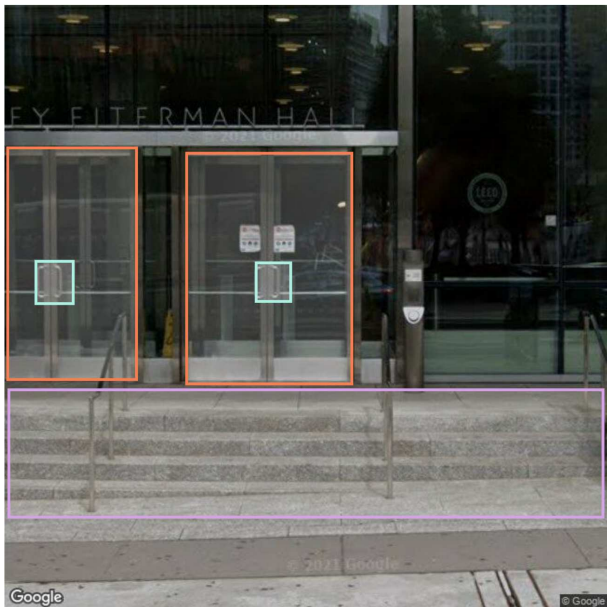

Fig. 1. Bounding boxes of doors, door knobs, and stairs on captured image

The data collected through DoorFront enables the development of mobile applications designed for mobility training and real-time assistive navigation. These applications can significantly enhance the ability of BLV people to travel independently by providing them with accessible, real-time information about their surroundings. However, assembling a high-quality, large-scale dataset requires substantial participation from volunteers, which presents a significant challenge.

To boost user retention and engagement, DoorFront incorporates a gamified user interface [3, 14]. This interface includes features such as a reward system, a leaderboard, badges, and mapathon competitions, which encourage greater interaction

among users on the platform. While these gamification elements effectively increases the volume of data collected, it does not achieve the desired impact within an optimal time frame. As a result, the availability of up-to-date and comprehensive accessibility information for BLV individuals' independent travel remains limited.

In this paper, we propose a user-centric, request-driven crowdsourcing approach to overcome these challenges. Our approach allows BLV individuals to send specific requests via DoorFront, including a store name or address, and planned travel time. These requests are broadcast within the DoorFront registered volunteer network through email and through the web-page. Volunteers can then collect the required data via the DoorFront platform or onsite by the specified deadline, ensuring timely and relevant data collection.

The contributions of this work include the following:

- Focus Group Study: We conduct a focus group study to understand the challenges faced by BLV individuals when utilizing collected accessibility data, as well as the motivations and experiences of high school volunteers engaged in data collection through DoorFront.org.
- User-Centric Crowdsourcing Approach: We develop a user-centric, request-driven crowdsourcing approach designed to enhance volunteer engagement and retention in gathering urban accessibility data. This approach also encourages BLV individuals to actively use the collected data, thereby bridging the gap between data collection and practical application.
- Preliminary User Study: We conduct a preliminary user study to evaluate the effectiveness of the proposed user-centric crowdsourcing approach, assessing its impact on both data quality and user satisfaction.

Through these efforts, we aim to create a more efficient and impactful system for collecting and utilizing accessibility data, ultimately empowering BLV individuals to navigate urban environments with greater confidence and independence.

II. Related Work

A. Urban accessibility crowdsourcing

Urban accessibility data, including sidewalk & storefront accessibility data, and public infrastructure data, is essential information for BLV individuals to plan independent travel. One of the novel approaches for data collection is the use of crowdsourcing. Recent studies have demonstrated the feasibility of crowdsourcing in web application [7,9,10]. Previous reports have examined the potency of crowdsourcing in urban settings and have found a high potential for data collection [3,4]. Applications such as Project Sidewalk have also demonstrated the incredible potential for virtual auditing of urban accessibility data [5]. A case study done on Project Sidewalk demonstrated a positive relationship between the usage of a crowdsourcing web application focused on digital civics and public understanding of pertinent issues in the disability community [11]. This case study also identified three key motivations for sustained engagement with the platform: "a sense of empowerment and accomplishment, socialization amongst community members and friends, and overall enjoyment." Our prior research [13] has often focused on increasing overall enjoyment of the platform, however socialization and the feeling of accomplishment are currently lacking on the DoorFront platform.

By focusing on a user-centric approach, volunteers can feel directly responsible for helping a specific BLV user, with the feature also facilitating indirect socialization between users and volunteers.

B. Gamification in crowdsourcing applications

Studies conducted on gamification in the context of crowdsourcing have demonstrated a positive correlation between the two. Gamified systems profoundly impacted crowdsourcing applications by increasing long-term engagement as well as increasing the quality of collected data [6]. Gamification has been proven to be highly effective especially when targeting a younger volunteer base, a demographic that DoorFront explicitly targets by awarding community service volunteer hour certificates to users, which many high school students require for graduation at various institutions [11]. The most commonly utilized forms of gamification in crowdsourcing applications are points or score-based systems, leaderboards or ranking systems, quests, and badge or achievement systems [12]. DoorFront has implemented the above gamification mechanics but the impact of these mechanics has been less than we anticipated.

Implementation of a quest-type system serves as more than just a gamification mechanic: requests allow users and volunteers to interact with each other. Through this system, BLV users can get the specific information they need and volunteers can feel the satisfaction of directly helping a person in need. This increases the likelihood of volunteers returning to collect additional data.

III. Methodology

A. Overview of DoorFront data collection and assistive navigation

The previous formative study [3] highlights that people who are BLV often spend significant time locating the entrance to a store or building upon arrival at their destination. To address this issue, DoorFront was developed to collect important accessibility and location data. The precise geographic location of each labeled accessibility object is calculated and stored in a database.

BLV users can then query a store name or address during their independent travel using the assistive navigation mobile app we developed, automatically generating a route to the location of the entrance. Unlike standard navigation apps, such as Google Maps or Apple Maps, which typically guide users to a general location (often the building's center), our app directs users to the precise geographic location (latitude/longitude) of the main entrance. Additionally, the navigation app displays our captured accessibility information, including the type and location of door knobs, door types, and the presence of stairs or

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accessibility ramps at the entrance. This ensures a convenient and efficient travel experience for users with BLV.

Our mobile app made for navigation targets BLV users who have access to a smartphone they can independently utilize. The BLV user requires an internet connection to access the servers that host storefront accessibility information.

B. Focus group study of BLV users and High school students

The relationship between data coverage and the adoption of assistive navigation using collected data presents a classic chicken-and-egg problem. The greater the data coverage, the more likely it is that BLV users will utilize the data during their independent travel. Conversely, increased user engagement can lead to more comprehensive data collection. To gain insights into how BLV users adopt urban accessibility data, we conducted a focus group study involving ten individuals who are blind or have low vision (6 female and 4 male, 3 blind and 7 low vision individuals). The participants were recruited through mailing lists and social media platforms, ensuring a diverse group of users with varying experiences and needs.

a) Focus group study of BLV users: The primary objective of this focus group study was to understand the criteria BLV users consider when choosing assistive technology for independent travel. We sought to identify features that might encourage more BLV individuals to adopt DoorFront data for their travel needs. Specifically, we aimed to explore preferences regarding the accessibility interface of DoorFront and to identify any barriers that might prevent users from fully utilizing its features.

We gained the following insights from the focus group study:

- Precise Location Importance: The BLV participants emphasize that having accurate and precise information about store entrances would significantly enhance their travel experience and ease their navigation in urban environments.
- Impact of Incomplete Data: The group note that incomplete or missing accessibility data discourages them from using the app for future travels, highlighting the importance of thorough and reliable information.
- User Interface Preferences: The BLV individuals express a strong preference for a simple and accessible interface, stating that such features would encourage them to adopt and regularly use the assistive technology.
- Appreciation for Volunteers: The participants express a desire to recognize and appreciate the efforts of volunteers who contribute to collecting accessibility data, underscoring the value they place on community involvement and support.

b) Focus group study of DoorFront volunteers: To understand the needs of volunteers and enhance their engagement, we also conduct a focus group study with high school volunteers who have contributed their time on the Doorfront platform. The study reveals that, while volunteers are eager to help the BLV community, they are unclear about who would use the data, when the BLV users would need it, how much data should be collected, and when the data collection should be completed. Additionally, there is no direct connection between the blind users and the volunteers. These factors significantly impact volunteer engagement and motivation.

C. User-Centric Design

By addressing the concerns discovered in the above focus group studies with a more structured and purposeful system, we have designed and implemented a new request system that takes input from BLV users and allows volunteers to directly respond to their requests.

The request interface features a simple loop highlighted in figure 2. By allowing BLV users to create requests, the data collected on the DoorFront platform will be much more pertinent to the needs of the BLV users. This system also facilitates the increased engagement of sighted volunteers as each request fulfilled can immediately be utilized by a BLV user, allowing for direct feedback and gratitude from users to volunteers, thereby creating a positive feedback loop. The privacy of our users is paramount, so anonymity is preserved through the use of nicknames defined by the user. BLV users can also choose not to include their nickname with requests if they require further privacy. This system can facilitate a sense of community on the DoorFront platforms, as volunteers will be able to directly help a BLV person instead of submitting data that may or may not help anyone. The utilization of an automated email system keeps both BLV users and volunteers up to date with the current state of the platform. This system has been demoed with both BLV users and sighted volunteers and has received positive initial feedback.

IV. Implementation

When a BLV individual signs up on DoorFront, they will be assigned the role "Blind or Low Vision Data Requester." Users with this role will have the functionality of the create request system available to them. All other user roles will be able to fulfill requests. The create request interface features a simple, accessible layout that was designed in conjunction with a low-vision tester over two testing sessions, the outcome of

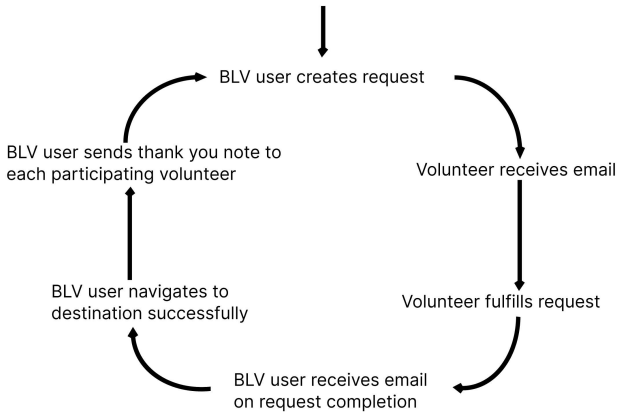

Fig. 2. Request Loop

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which will be detailed in the Evaluation section. We used large text size and high contrast text and background combinations to make the system easy to use for the visually impaired. Components such as buttons and text boxes are also labeled with alternate text for screen readers so blind users are able to use the interface.

The create request interface also allows users to ask for labeling in a mile-radius around the requested address or at just one specific address. Users can set a deadline if they so choose if the need for data collection is urgent. When the request is submitted, an email is sent to all volunteers that opt in to the request program, informing them that a new request is available to complete. A link in the email takes volunteers to the fulfill request interface on DoorFront. From there, volunteers can label the requested address or area to the best of their ability. The interface features a simple table with the following columns: requester name, type of request, address, deadline, and a fulfill button. The table is sorted by nearest deadline, and volunteers can click the fulfill button to navigate to the address through the GSV interface on the Explore page. Labels captured in a request area grant double the points as a normally captured label, further incentiving users that enjoy interacting with the gamified systems. As with all submitted labels on DoorFront, one volunteer submits the labeled image and two volunteers verify the labeling is correct. Once all three volunteers have reviewed the labels, the image is submitted to the database for use in navigation. For single address requests, only one image must be submitted for the request to be marked complete. For areas, once a single image is completed in the request area, the request is marked in progress until the deadline. If no deadline has been set, the BLV user who submitted the request will receive an email to alert them that submissions have been made in the requested area.

The final part of this request loop is the assistive navigation app (Sec. III-A) and letter of appreciation. Once the user has successfully navigated to their desired location, they can send a thank-you email to the volunteers that participated in the collection of the requested data. This thank you letter serves to close the loop, allowing volunteers to feel appreciated thanks to their contributions and for users that are blind or have low vision to navigate to a location much easier.

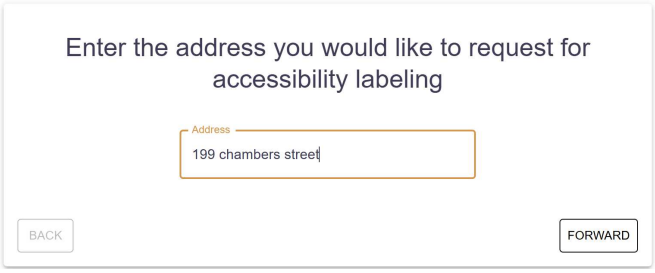

Fig. 3. Create Request Page 1

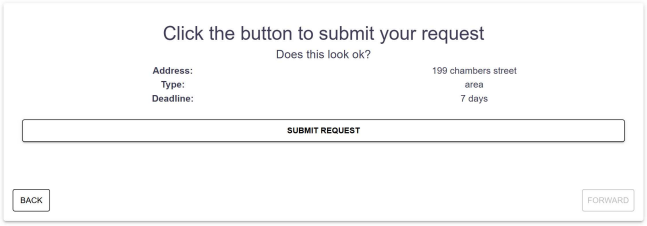

Fig. 4. Create Request Page 4

V. Evaluation

A. Interface design evaluation from BLV user

The request system went through multiple revisions before we settled on a design that allows for users to submit the request. To facilitate this, we worked closely with a low vision student (a BLV tester) to test the interface in multiple stages. Feedback on the user experience, accessibility level, and the system itself are recorded during two test sessions.

During the first testing session, we demo a prototype version of the created request interface. Initial reactions to the request concept are very positive; the tester indicate their desire to use the application in the future. The interface consists of five pages the user must navigate through to successfully submit the request. Round one of testing elucidates some concerns, mainly focused on color choices, extraneous or distracting elements of the interface, element spacing, and clarity of language used. The tester raises concerns about the colors used, as the shade of orange on the buttons as well as the dark blue text becomes blurry when used with color inversion. The heading menu bar that is present on every DoorFront page causes confusion, as the tester spends more time reading the menu bar rather than engaging with the interface. Closeness of element spacing and the number of buttons is pointed out as a possible concern, as more time is spent trying to understand and read through the interface than actually filling out the necessary information to submit the request. Navigation between pages is handled using arrow buttons, but the tester has some issues with the size of the arrows as the legibility is not great. Language used such as the term “point” when picking between an area or single address request brings hesitation from the tester as the language could be interpreted in different ways. Similarly, the phrase “data collection” in the sentence “please enter an address for data collection,” brings unnecessary confusion. Finding a balance between concise but descriptive language is a focus for the next stage of testing. Overall, the main takeaway from the first testing session is to make the interface as simple as possible to expedite initial understanding and usability.

We revise the interface and test again with the same tester. The second revision serves to be much clearer for the tester; extraneous use of color is lessened, the menu bar is removed, the text size increases, the number of buttons reduces, and the page navigation is changed to white buttons with black text and borders to enhance clarity. The second round of testing

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receives more positive feedback compares to round one. The tester appreciates the simplicity and ease of use of the new approach. An aspect that could still be improved is noted to be the home page, as BLV users would still need to navigate the home page to sign up for a new account and login when returning and the tester display an inability to navigate back to the create request interface from the homepage. At the start of the test, the user is handed the phone with the correct web page already opened, but if they want to navigate to the interface on their own it may prove to be difficult. The tester also expresses an interest in accessibility features built into the web page, rather than having to rely on built-in smartphone options. Both pieces of feedback have been taken into consideration for the final version of the interface.

B. Evaluation and Feedback from Volunteers

We ask volunteers to test the new feature and they are able to complete the request in less than one minute. They find the new interface is easy to follow. In addition, we also ask volunteers to complete a survey regarding the new request-driven feature, and their feedback has been very positive. They find the new approach more efficient, as it ensures the data they collect will be utilized, rather than volunteers labeling random locations that may not be needed soon. Additionally, it provides volunteers with specific locations to label, which can be done in seconds.

Feedback on this new feature includes comments such as, "I think it creates a much more efficient way to get information," and "I think volunteers would be more inclined to label doors if they had a set place to label." Having BLV users make direct requests with deadlines is preferred by volunteers. Another recently considered feature is creating a thank-you note for volunteers after fulfilling a request and when another BLV user later uses that location. Since it has already been labeled by a volunteer, other BLV users can directly use it, making the data more useful. It appears that 66% of volunteers prefer receiving a weekly email summary showing the number of times a location they labeled has been used. This weekly summary might also encourage volunteers to continue fulfilling BLV user requests.

VI. Conclusion

The crowdsourcing approach for collecting urban accessibility data presents challenges in ensuring both data quality and quantity. To address these issues, we propose a user-centric, request-driven crowdsourcing app designed to gather storefront accessibility data for people who are blind or have low vision (BLV). This approach allows BLV users to request specific accessibility information. By aligning the interests of both BLV users and volunteers, we ensure that the data collection process is efficient and impactful, meeting the real-world needs of BLV individuals.

Our user study shows positive feedback from both BLV users and volunteers. BLV participants reported that the app significantly improves their travel experience by providing precise navigation to storefront entrances. Meanwhile, volunteers found the platform engaging and rewarding. The request-driven model increases user engagement and ensures that the collected data is relevant and useful, ultimately facilitating greater independence for BLV individuals. Our approach successfully addresses the challenges of crowdsourcing urban accessibility data, offering a scalable solution that enhances the quality of life for people with visual impairments. Future work will focus on conducting more user studies and refining the platform based on user feedback. Sustaining volunteer engagement is one of the primary goals of our continuing research; We continuously explore new strategies to enhance volunteer engagement and collect large-scale urban accessibility data.

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References

[1] "Fast Facts of Common Eye Disorders." Centers for Disease Control and Prevention, Centers for Disease Control and Prevention, December 2022, www.cdc.gov/visionhealth/basics/ced/fastfacts.htm

[2] Ye, J. (H.), & Jensen, M. (2022). Effects of introducing an online community in a crowdsourcing contest platform. Information Systems Journal, 32(6), 1203–1230.

[3] Liu, Jiawei, Tang, Hao, Seiple, William and Zhu, Zhigang. "Annotating Storefront Accessibility Data Using Crowdsourcing Journal on Technology & Persons with Disabilities." Volume 10, June 2022, pp 154-170.

[4] Marzano, Gilberto, Joanna Lizut, and Luis Ocha Siguencia. "Crowdsourcing Solutions for Supporting Urban Mobility." Procedia Computer Science, vol. 149, 2019, pp. 542–547.

[5] Saha, Manaswi, et al. "Project Sidewalk: A Web-Based Crowdsourcing Tool for Collecting Sidewalk Accessibility Data at Scale." Proceedings of the CHI Conference on Human Factors in Computing Systems, May 2019, pages 1–14.

[6] B. Morschheuser, J. Hamari and J. Koivisto, "Gamification in Crowdsourcing: A Review," 2016 49th Hawaii International Conference on System Sciences (HICSS), Koloa, HI, USA, 2016, pp. 4375-4384.

[7] May, Andrew, Christopher J. Parker, Neil Taylor, and Tracy Ross. "Evaluating a Concept Design of a Crowd-Sourced 'Mashup' Providing Ease-of-Access Information for People with Limited Mobility." Transportation Research Part C: Emerging Technologies, vol. 49, 2014, pp. 103–113., doi:10.1016/j.trc.2014.10.007.

[8] Hill, E., & Ponder, P. (1976). Orientation and mobility techniques: A guide for the practitioner. New York: American Foundation for the Blind.

[9] Krajzewicz, Daniel. "Traffic Simulation with SUMO - Simulation of Urban Mobility." Fundamentals of Traffic Simulation, 2010, pp. 269–293.

[10] Marzano, Gilberto, Joanna Lizut, and Luis Ocha Siguencia. "Crowdsourcing Solutions for Supporting Urban Mobility." Procedia Computer Science, vol. 149, 2019, pp. 542–547.,

[11] Chu Li et. al. 2024. "I never realized sidewalks were a big deal": A Case Study of a Community-Driven Sidewalk Accessibility Assessment using Project Sidewalk. In Proceedings of the CHI Conference on Human Factors in Computing Systems (CHI '24). Association for Computing Machinery, New York, NY, USA, Article 969, 1–18.

[12] Hallifax, Stuart & Altmeyer, Maximilian & Nagel, Kristina & Rauschenberger, Maria & Nacke, Lennart. (2023). From Points to Progression: A Scoping Review of Game Elements in Gamification Research with a Content Analysis of 280 Research Papers. Proceedings of the ACM on Human-Computer Interaction. 7. 748-768. 10.1145/3611048.

[13] Ortiz, Tyler & Tang, Victor. (2024). Improving Urban Accessibility Data Collection through Enhanced User Experience in a Crowdsourcing Web Application. 55-59. 10.1109/ICICSE61805.2024.10625690.